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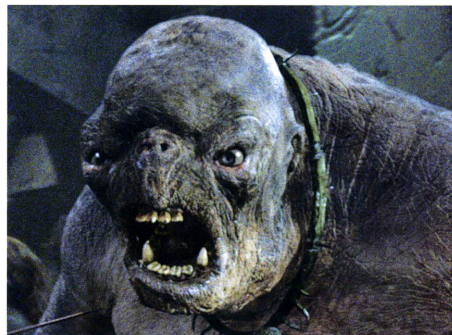
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Few would argue that effects technology has changed since *Cinefex* made its debut more than 22 years ago. Photochemical composites were the industry mainstay then, and computers were little more than data wranglers that ran motion control systems, the latest trick in the visual effects magic show. So much has changed.

We've changed, too, at least in our editorial focus, keeping current and keeping our readers up to date on the ever-advancing world of visual effects. What hasn't changed much is our appearance. Aside from a modest design tweak almost ten years ago, *Cinefex* has continued to look pretty much the way it did when we started.

For some time, however, we've been contemplating a new look for the magazine. My eye-strained editor and proofreaders pleaded for a larger, more readable typeface; I wanted a more flexible template for laying out text and photographs. Beyond that, I decided to invite a design professional, Michael Gross, to spruce up the overall look of the magazine.

Michael and I have been friends since high school. We worked on amateur movies and magazines together, and he designed my first book more years ago than either of us would care to admit. (As he is fond of reminding me, I cribbed shamelessly from that design when I devised the seminal layout for *Cinefex* way back when.) Michael was the founding art director of *National Lampoon*, then went on to art-direct *Esquire* before transitioning into the motion picture business. During a long association with director Ivan Reitman, he earned a range of producing credits on a dozen or more films, including the *Ghostbusters* movies, *Twins* and *Kindergarten Cop*. He focuses today on painting and photography. Michael is a fine designer with a great aesthetic; but in gently reworking *Cinefex*, he gave me just what I wanted — no more, no less. Anything you like about the new look, you can credit to Michael. Anything you don't, you can credit to the constraints I placed upon him.

We encourage you to write and let us know what you think. The timing is fortuitous, because we're incorporating a new 'Letters to the Editor' section into our website. Personally, I enjoy reading letters in other publications; but never included them in *Cinefex* because I didn't want to give up the editorial space. The Internet allows us to have it both ways. So feel free to sound off, on any topic, and we'll post the best of what we receive.

And while you're at it, check out some of the other features on our site. In addition to a thorough index of all our back issues, we maintain an informative compilation of data on effects films currently in production. Plus you'll find a full-length bonus article on *Clockstoppers* — the new science fiction film from producer Gale Anne Hurd and director Jonathan Frakes. All of this, and more, is available only on-line at www.cinefex.com.

Don Shay

The Shape Of Things To Come

ARTICLE BY JOE FRANCIS



Five years before the dawn of the twentieth century, H.G. Wells assembled a story he had written and serialized in magazine form into his first published novel — a dark tale about a time traveler who journeys deep into the unforeseen future. *The Time Machine*, which defined Wells as a visionary author and one of the earliest purveyors of science fiction, would become a literary classic. Many years later, the novel would be given cinematic life by acclaimed science fiction and fantasy filmmaker George Pal, who parlayed the book into a 1960 special effects Oscar-winner. Now, in a serendipitous turn of events, Simon Wells, the great-grandson of H.G. Wells, has taken up the reins of his forebear's legacy, making his live-action directing debut with an adaptation of the nineteenth-century work, reformulated for twenty-first-century audiences.

Wells spent most of his career in animation before making the leap to live-action. Working under Steven Spielberg for more than a decade, he was a supervising animator on *Who Framed Roger Rabbit* and was instrumental in helping to set up Amblimation in London. From there, he went on to direct a number of animated features, including *An American Tail: Fievel Goes West* and *The Prince of Egypt*. Having often told Spielberg of his wish to move from animation into live-action, Wells wasted no time in pleading his cause when negotiations began between DreamWorks and Warner Brothers for a remake of *The Time Machine*. “I spoke to Jeffrey Katzenberg, with whom I was working at the time on *Prince of Egypt*,” recalled Wells, “but Jeffrey didn’t hold out much hope. Then I got to meet with producers Walter Parkes and Laurie MacDonald and discuss some story ideas I had for the script. I talked about how I felt I could strengthen the movie and where I’d like to go with it. They said, ‘Thank you, we’ll think about it,’ and went on to talk with a lot of other directors. Finally, they came back to me, and said, ‘Actually we think you’ve got the best take on the film, so you’ve got the gig.’”

Loosely adapted from the original novel, the story was given a considerable makeover by screenwriter John Logan, who relocated the setting from London to New York and added several new characters and plot twists. “We did quite a lot of adaptation, as did George Pal in his version,” Wells explained. “The original book is frankly a rather depressing piece. At the end of the day, the time traveler travels so far into the future that he sees the end of all life on earth, and he never does anything about it. You might think that I, more than anybody, would feel a responsibility to be extremely faithful to the original book— but that wasn’t the case. This will probably get me lynched by the H.G. Wells Society, but I felt that if anything, I, better than anybody else, had the right to take liberties with the story.”

The new narrative would concentrate on events in the life of Alexander Hartdegen (Guy Pearce), a brilliant nineteenth-century mathematics professor, whose time travel theories are put to the test with a time machine of his own invention. Following the tragic death of his fiancée, Emma (Sienna

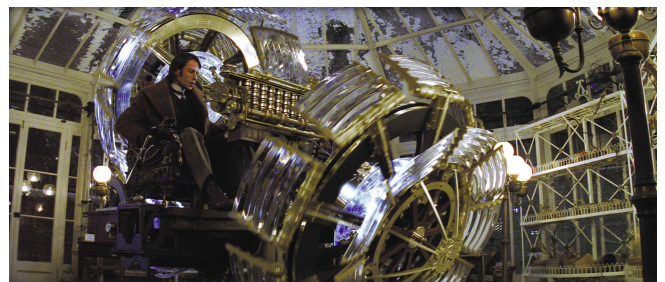
Guillory), and with nothing to live for in the present, Alex wanders deeper and deeper into the future, eventually reaching a dystopian society 800,000 years forward in time. There he encounters and befriends the Eloi, a gentle race of humans whose peaceful existence is imperiled by a savage subterranean race of human mutants known as Morlocks.

Given the span of its narrative, *The Time Machine* represented a mammoth cinematic undertaking. To handle the challenges, Wells and visual effects producer Kim Nelson drew upon the expertise of visual effects supervisor James E. Price, whose most recent work included a two-year stint with Disney, where he oversaw effects for *The Kid* and *Bicentennial Man*. Price broke the effects work down into four distinct environments, delineated by Wells' storyboards. "We start in New York in 1899," explained Price, "then travel to the year 2030. Finally we travel far beyond that, to the year 802,701, which consists of two environments—the forests of the Eloi and the caverns of the Morlocks. Each of these environments posed its own challenges, and served as the basis for organizing the effects work. We also broke it down along the lines of specific techniques."

Faced with some 450 visual effects shots, Price and Nelson opted to divvy up the workload among a number of effects houses, playing to the strengths of each. Heading the effort was Digital Domain, responsible for approximately 250 shots involving the movie's signature time travel scenes. Illusion Arts was engaged to produce 2D and 3D enhancement of the Victorian and future world environments, while Cinesite, in addition to miscellaneous wire removal and compositing chores, took on a key climactic sequence. Practical creature effects—specifically the Morlocks and an über-Morlock villain—were the work of Stan Winston Studio and KNB EFX Group, with Industrial Light & Magic extending those performances via CG character animation. Finally, special effects supervisor Matt Sweeney oversaw practical effects, including creation of the fabled machine.

The Time Machine opens in a Columbia University classroom, where Alex is attempting to explain his time travel theories to his students. For exterior shots of the period New York City setting, filmmakers selected historically preserved neighborhoods in upstate Albany and Troy. While live-action photography of the quaint streets provided a good starting point, the presence of historical anachronisms such as modern street lighting necessitated a redressing of the neighborhoods, by production designer Oliver Scholl, with period signage, street lamps and horse-drawn carriages. In a vacant lot on a particularly picturesque street, construction crews built a two-story façade to represent Alex's townhouse for the three-and-a-half weeks of exterior filming. Since February snow covered the neighborhood, the special effects department had to dress the façade to match. "My set operations foreman, Bob Stoker, ran chunks of ice through chippers and blew the resulting frost over everything," said Matt Sweeney. "It has that sparkle you just don't get with artificial snow."

Given the absence of specific landmarks, such as Fifth Avenue mansions, the New York Public Library and Central Park, Price called upon the Illusion Arts team, supervised by Syd Dutton and Bill Taylor, to provide matte paintings that would help complete the transformation of modern Albany into Victorian Manhattan. In order to make the work as straightforward as possible, Price tried to capture as



In *The Time Machine*, scientist Alexander Hartdegen (Guy Pearce) invents a device that allows him to journey

much as he could in-camera, relying on paintings primarily to enhance or extend what was already on location. Although Wells was shooting within the 2.35:1 aspect ratio of the anamorphic movie format, all plates intended for enhancement by Illusion Arts were captured in eight-perf Vistavision. Price chose the larger format for a familiar reason— its extra image area would facilitate the imposition of

postproduction camera moves over the otherwise still paintings— but added a literal extra twist to the technique. “We did a clever thing with all the matte paintings, particularly in New York,” Price said. “In the shot where we establish the city skyline, panning across it before tilting down onto Alex’s street, we took our Vistavision camera and rotated it 90 degrees on its side. This gave us an eight-perf frame, running vertically, which provided a tall image from which to extract the 2.35 aspect ratio image. Then we extended the skyline off to the left with a matte painting. That gave us the ability to drift across into the top of our tall Vistavision plate and do a significant tilt-down in post, without having to tile together smaller film plates or worry about seams and the difficulties of extras crossing over those seams.”

Early in the film, Alex runs across snowy Fifth Avenue to meet Emma in Central Park, where he plans to propose to her. Price could not find a suitable stand-in for the wide Manhattan boulevard, so he manufactured one. “We found a road in Albany that had a park along one side, but it was only two lanes wide, not the five lanes that spanned Fifth Avenue in 1899. To digitally widen the road, we sent all of our horses and carriages and extras down it, away from camera, and shot a left-side plate from a crane. Next we moved the camera— at the same height— to the opposite edge of the road and, with the traffic returning toward camera, filmed our right-side plate. When we split the two plates together, we achieved the width we needed.”

In addition to 2D Photoshop work, Illusion Arts matte artists Kelvin McIlwain and Michael Kory used Maya 3D CG renderings to dress the left-hand side of the frame with the elegant mansions of the era’s moneyed gentry, then used Adobe AfterEffects to add Alex to the composition. “The final element in the multilayered shot was a separate take of Alex weaving through the traffic,” stated Price. “We didn’t want to endanger the actor, so we filmed him alone in snow and timed his weaving to a choreographed gap in the traffic pattern. The shot came together well because we were careful to avoid introducing inadvertent camera drift between the split elements due to crane motion. Had the wind or our crew jostled the crane it would have been a real problem, because unlike ‘nodal point’ camera rotation or weave, the resulting camera translation between the left- and right-hand plates would have introduced perspective shifts not easily steadied in post.”

through time. Director Simon Wells – great-grandson of H.G. Wells, who authored the original tale – called upon visual effects supervisor James E. Price to orchestrate the production of time travel imagery and a range of environments spanning some 800,000 years. Special effects supervisor Matt Sweeney oversaw construction of a full-size mechanized model of the machine, which, in operational mode, was augmented digitally by lead visual effects house Digital Domain.

Emma accepts Alex's proposal of marriage, but the joyous moment turns tragic when a mugger confronts them, and Emma is shot and killed in the ensuing struggle. The narrative then jumps ahead four years to find a still-grieving Alex in his home laboratory. In a greenhouse attached to the lab sits a time machine—the fruits of four years' labor and the instrument that Alex hopes will enable him to travel into the past and alter Emma's fate. The time machine, as conceived by Simon Wells and Oliver Scholl, would differ somewhat in appearance from the earlier George Pal version. "From the first discussions," recalled Wells, "we always knew our machine should feel like a functional prototype, not an elaborately decorated piece of Victoriana. We wanted it to have the inherent beauty of the handcrafted scientific equipment of the time, and the sense of power of a steam engine. Oliver and I began with the basic idea of a spinning disk, because that was part of the original George Pal machine that we had loved so much. Then we discussed the fact that we had both been confused about how all of that machine traveled through time, even though some of it was outside the disc. We started sketching spherical time fields, with discs generating the field. It was Oliver's idea to have a central 'bomb' that generated the field, then use the discs to spread it. I brought in an obscure reference from the original book that the time traveler was a professor of physical optics; so I suggested deriving our discs from the Fresnel lens systems of lighthouses—a very Victorian piece of technology. We deliberately never attempted to explain any scientific rationale for why the machine works. Too often in movies, a piece of bogus science is rolled out to impress the audience, and it sounds fake."

Design ideas were tested and pinned down in the production art department, where digital illustrator Tim Wilcox modeled them in LightWave. "Oliver had done a couple of sketches with Simon," Wilcox stated. "Then I began building 3D models. We were all in on the designing. They'd say, 'Well, let's try this,' and I'd be the guy who had to figure out how to make it." The final design would reflect the time machine's Victorian-age context, both in form and hypothetical function. "We designed it to represent what you might call Victorian high-tech," Jamie Price related. "Each component of the machine is based on technology and materials—mostly brass, cast iron, wood and lots of glass—that were available at the time. Probably the most dramatic design elements are the twin sets of rotating glass blades. These blades are arranged in two hemispherical sets, one behind Alex and one at his feet. As the machine is powered up, they open and begin to spin, focusing light energy that emanates from a boiler at the center of the machine. When the machine is at full power, the blades direct the light energy into a sphere that encases the machine as it travels through time."



Establishing shots of Manhattan – circa 1899, when the narrative begins – were filmed in historically preserved sections of Albany, New York, which were cleansed of anachronistic elements and digitally extended by Illusion Arts, another of the effects companies enlisted by Jamie Price to handle the visual effects assignment. Matte painters Kelvin McIlwain and Michael Kory employed 2D and 3D effects to widen an Albany stand-in for Fifth Avenue and border it with the elegant mansions of the era.

Assembling the various design ideas, Wilcox built a low-rez animated version of the reimagined machine, and then began addressing how it would articulate in the real world. “At that point,” Wilcox said, “Oliver had a couple of model guys come in—Andrew Jones and Dana Yuricich—and I printed out giant orthographic views to scale. They took what I had done and brought it to life as a G.I. Joe-scale model that was fully articulated. The whole point was to figure out how we were going to get the mechanics to work. Plus, it gave us a tactile environment where we could touch and grab parts and move things around.”



When Alex activates his invention, opposing glass discs begin to spin at high speed – an effect achieved digitally – producing a temporal energy field defined by a luminous sphere that surrounds and protects the device and its occupant. Artists at Digital Domain, under visual effects supervisor Erik Nash, employed high dynamic range imaging techniques to impart maximum variability and detail to the glowing bubble effect.

Creation of the machine as a full-scale live-action prop fell to Matt Sweeney. With less than three months to complete the job, Sweeney gathered a crew of twenty-five—headed by prop shop foreman Andy Miller—and raced to meet the deadline, working closely with Wilcox and set designer Daryl White to translate the 3D model into the physical realm. “We had always planned to do a digital model,” noted Wilcox, “because we knew we’d be doing visual effects and we wanted to avoid everybody reinventing the wheel and rebuilding something we’d already done. But we didn’t know whether that was going to help us in building the actual prop.” It soon became apparent, however, that the digital prototype could be used in conjunction with computer controlled tooling equipment to duplicate, quickly and precisely, many of the time machine’s essential components. Running twelve hours a day, every day, for two months, Sweeney’s tooling machines cranked out hundreds of parts based on geometry files submitted by Wilcox and blueprints created by White.

The finished construct weighed in at 6000 pounds and was mechanized by a three-horsepower variable-speed electric motor hidden in its base. A motion base aided in the shooting, enabling camera crews to rotate the device and vary the camera angles or simulate dolly moves around it, without having to construct a two- or three-wall greenscreen or build a huge set.

Alex travels back in time four years, only to learn that the machine will enable him to change the circumstances, but not the fact, of his fiancée’s demise. With nothing left to live for in his Victorian New York present, Alex decides to explore the future. While his first passage through time had occurred offscreen—mainly seen as a glow in the greenhouse workshop window—this time it happens onscreen, affording audiences their first real taste of time travel. Filmed against greenscreen, the prop machine’s real spinning blades were replaced with CG ones created by a team at Digital Domain under



Among Digital Domain’s most ambitious achievements was a dramatic pullback that begins just above Alex’s greenhouse laboratory, with the powered-up time machine visible within. In a circuitous maneuver, the camera spirals up and over Manhattan and continues on through the

visual effects supervisor Erik Nash, and tracked into the plate photography. Also computer generated by Digital Domain was the luminous bubble of energy known as the 'time sphere' that surrounds and protects the powered-up vehicle and its occupants. The sphere would serve as an important visual cue, adding drama to the time travel shots and reinforcing in the minds of the audience the notion that the machine was a high-tech, high-energy device capable of warping the very fabric of time.

Among Digital Domain's most ambitious achievements was a dramatic pullback that begins just above Alex's second, all-digital shot, the entire twentieth century is revealed in a nutshell – from the rise of sprawling metropolises to advances in air and space travel up and over Manhattan and continues on through the atmosphere and into space, eventually coming to rest beyond the moon. During the course of the thirty-five-second, all-digital shot, the entire twentieth century is revealed in a nutshell – from the rise of sprawling metropolises to advances in air and space travel.

Rather than render such energy effects in the usual manner, Nash and his crew turned to the writings of CG researcher Paul Debevec, who had presented a paper at the 1997 Siggraph convention in which he outlined a technique that allows digital artists to retain much more detail in their work — detail often lost to clipping at the high end and crushing at the low end of computer renderings and environment maps. "With this technology," explained CG supervisor David Prescott, "we can gather data about the lighting conditions of an environment by shooting it either with wide-angle fisheye lenses or reflective chrome balls. Then we bracket the photography over a range of eight or more f-stops and compile it all into a single HDR— high dynamic range— image that can be stopped up or down at will in the computer. For example, using this format we can take the image of a blown-out, flat-white light bulb, entirely lacking in detail, and— in compositing— dim it to the point where we can actually resolve the glowing filament within." This ability to resolve detail in bright image areas enabled the artists to greatly improve the look of the time machine's radiant time bubble.

In his first major onscreen trip through time, Alex travels from 1899, through the entire twentieth century, to the year 2030, where he stops to look around. During this foray in the machine— which he experiences in mere minutes— the slow march of time breaks into a frantic dash as Victorian-era structures are ultimately replaced by twenty-first-century high-rises.

In conceiving the sequence, Price needed to work out some creative strategies to help guide the process. Conferring with Wells, he devised a set of conventions that would govern the look of this and later sequences. "We initially approached it from the standpoint of logic," Price said. "One rule we determined was that Alex and his machine would be undetectable while he was traveling, because he would occupy what physicists call 'a singularity'— an infinitely small point in space. Another was that while the world could not see him, for dramatic reasons he would be able to see out into the world as it changed. Still another was that his machine could only travel in time, not space."

Occasionally, for aesthetic reasons, the filmmakers broke their own laws. For example, if the character were truly undetectable while time traveling, his luminous, but invisible, machine should cast no light on the surrounding environment. "We decided, in the interest of realistic-looking composites, that the time machine's light would affect the physical world, and vice versa," Price stated. "To do otherwise would have resulted in fake, pasted-in composites."

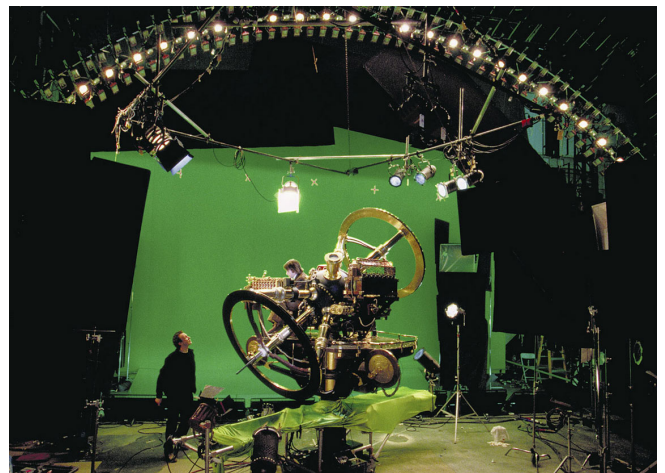
Given that decision, interactive illumination was rigged on set above the time machine to represent the sun flashing across the sky at an increasingly accelerated rate. “Production gaffer Steve Mathis and the electrical department created a programmable row of lights that could be run from a computerized dimmer board,” Price related. “This arc of Las Vegas-style tracer lights, which spanned 180 degrees, was suspended over the set. Using that device, we could create an interactive sun source that appeared to move from horizon to horizon— faster than any single light source could safely move on set— until it became a continuous band of light.”

It was also necessary to envision, and then depict, the changes in the immediate environment as the time machine travels into the future. “The machine is in a greenhouse off Alex’s home workshop,” stated Nash. “As he goes forward in time, the shop empties and becomes an automotive garage, and we see car styles change over the years as they zip through the space. We also observe — in a shot that reprises a similar one in the George Pal movie— the changing hemlines in a dress shop window across the street. Eventually we enter the twenty-first century, where an animated video billboard advertising lunar colonies stimulates Alex’s curiosity enough to make him pause and investigate.”

To achieve the rapid-fire transitions, Nash and Price settled on a simple stop-motion approach. “We did a pass in which we shot the set full of stuff,” Nash stated. “Then we removed twenty percent of the props, and shot another pass. We did about six steps this way to empty the room. In the composite, we split the frame a lot to produce more increments, so that we weren’t limited to just the six original steps.”

While Simon Wells liked the basic look, he wanted something more. Nash obliged with additional digital manipulation of the plate photography. “Before an object was to disappear,” noted Nash, “we’d isolate it and do a 2D blur on it, as if it were being removed from the frame. This gave the work a nice, ethereal, fluid quality— instead of just popping off, you got a sense of motion. We also took long-exposure digital still photographs of some of the guys on the crew doing generic movements against a black background. We would print these people in as ghost figures you would see now and then for a frame or two. It gave a nice human presence to the space being emptied.”

When shots went beyond the limits of what an ordinary live-action camera or even a motion control system could capture, Digital Domain introduced 3D CG into the mix. In one such shot, an orbiting pullout from Alex’s lab that travels up and around before returning to the greenhouse, plants appear to grow at a phenomenal pace, snails race by and



For shots of the time machine in operation, the practical prop was filmed against a greenscreen so that rapidly changing backgrounds could be photographed separately or computer generated and placed around it. The glass blades on either end of the prop machine were removed and subsequently replaced with spinning replicas, computer generated by Digital Domain. A programmable arc of tracer lights, rigged above the set, produced interactive illumination on the machine to impart the illusion of the sun’s traversing the sky at an accelerated rate.

spiders ricochet as they spin their webs. It was the kind of subject matter impossible to film with a smoothly dolly camera. For the plant growth, artists relied extensively on a technique known as L-systems, which employs a collection of rules that define a mathematical ‘grammar’ for describing plants. Using recursive procedures that exploit the similarity inherent in botanical forms, these systems could ‘grow’ realistic-looking and detailed foliage without a great deal of animator intervention.

More conventional CG techniques were used to produce the snails and spiders, with the artists focusing more on creative concerns than technical ones. Snail locomotion and spider web-building, both rather slow activities, had been chosen because, speeded up, they would help sell the notion of the passage of time. But there was always an inherent concern that if snails zipping around looked silly, audiences might be pulled out of the movie. Though Price and Wells had employed logic to guide the pace of the CG animation, they soon found they needed to bend that logic for artistic reasons. “We would have been unable to even see the snails and spiders if we had strictly adhered to the idea that each frame of animation represented three days of real time,” commented Prescott. “We smoothed out much of the fussy details of their motions; but we did not smooth everything. We elected to insert staccato pauses into their behaviors that were just long enough to allow the audience’s eyes to register their shapes. We also chose, in the interest of satisfying audience expectation, not to smooth out the way a spider’s web bounces during time-lapse photography.”

The essentially intimate scope of the first time travel sequence would be broadened much later in postproduction, when Wells viewed a rough cut of the film. “Simon felt that the scale of the sequence— especially in comparison to a second time travel scene where we cover 800,000 years of geological history— was just too intimate,” said Nash. “It was all an examination of the changes taking place in Alex’s immediate environment. The idea was put forward that what we really needed to see were the technological changes that epitomized the twentieth century— the growth of Manhattan, the development of air travel, and subsequently of space travel.”

In September, with less than three months remaining in a tight postproduction schedule, Digital Domain commenced work on what would become one of the film’s most ambitious shots— a ‘powers-of-ten’ view of the changing world in which the camera, in one elegant pullback, moves up from the greenhouse, through the atmosphere and into space, eventually looking back toward earth from beyond the moon. It was left to Digital Domain visual effects producer Julian Levi and his team to figure out how to create the gargantuan shot in a mere ten weeks.

Storyboarded by Wells, the thirty-five-second shot begins just above the greenhouse with the time machine inside. As the camera rises above the neighborhood, a blur of activity reveals buildings being constructed and torn down. The pullback accelerates and an early airplane passes through frame, then skyscrapers ‘grow’ toward the camera in time-lapse fashion. Receding further, the camera reveals a multi-engine propeller plane, then a jumbo jet. Higher still, lights are seen springing up across



Inside the twenty-first-century New York Public Library, Alex encounters a virtual librarian called ‘Vox,’ who appears in the form of a holographic projection, moving about inside a standing array of glass panels. For the most part, shots of Vox (Orlando Jones) were

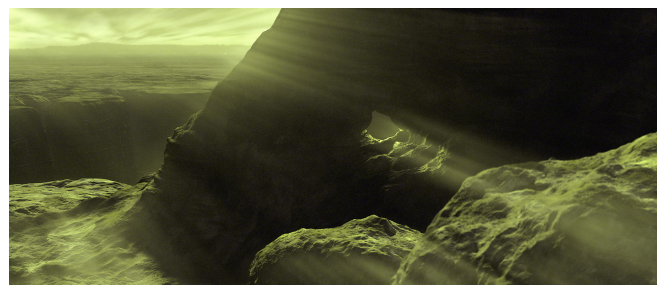
the eastern seaboard as the metropolitan area expands. Now out in space, a progression of satellites comes into view, from Telstar all the way to the International Space Station, with changing weather patterns illustrating the further passage of

accomplished in-camera, with the live actors performing on either side of a pane of real glass. During postproduction, Digital Domain provided image enhancements to accentuate Vox's non-physical presence.

time. The shot culminates with a futuristic space shuttle coming at camera from the earth. It does a big, sweeping turn as the camera settles, framing half of the moon and revealing the beginnings of a lunar colony on the dark side of the moon. "The beauty of this shot," stated Nash, "was that it gave us the grand scale we were after—the history of the century, both in its growth of the city and population expansion, and by air and space travel. But it also took us to the lunar colony, which led into the moving billboard—the reason Alex stops and gets out to investigate."

Given its dramatic camera move, the pullback was planned as an all-CG shot. Nash and Prescott began by developing 3D animatics, based on the 2D animatic that the production had created from the storyboards to establish a rough timing for the shot. "Everything started out in the initial animatic as correct as possible," said Nash. "Certain things were later cheated, like the altitudes of the airplanes and satellites, just for timing and compositional reasons; but the relative sizes and distance of the earth and moon are accurate. Previz integration lead Zachary Tucker took on this difficult task of previsualization."

Complicating the shot considerably was the corkscrew nature of the initial camera move. "Typically these powers-of-ten shots are done in purely 2D fashion," Nash remarked, "where you conveniently limit the camera to a straight pullback, which minimizes perspective shifts and all of the complications associated with that. But Walter Parkes pitched the idea that rather than doing just the textbook powers of ten, we spice it up a little by making more of a circuitous flight around the neighborhood as we rise above Manhattan. To do that, the low end of the move had to be completely 3D, because we're down in amongst the buildings, and we fly very close by an eighty-story skyscraper in the process of being built. Not until we got high over Manhattan did we get to the point where we could use 2D solutions."



Wind and water erosion carve the earth as the untended time machine carries Alex thousands of centuries into the future. These shots were part of an all-CG showcase sequence, designed and executed by Digital Domain, that depicted, in mere seconds, the passage of eons of time in geological terms. Artists used proprietary tools and an array of techniques to render richly detailed, virtual landscapes and infuse them with atmospheric effects, then animated them to reflect the violent upheaval.

Intrigued by the video billboard advertising lunar colonies, Alex halts the time machine for a closer look. C.O.R.E Digital, under supervisor Doug Masters, produced the thirty-second futuristic infomercial in the flavor of a time-share advertisement, done mostly with 2D graphics. Digital Domain processed the digital files to give the imagery the look of a self-illuminated screen, and composited it onto a thirty-by-forty-foot bluescreen framework erected and photographed on the backlot at Universal Studios.

Establishing shots of twenty-first-century New York featured a handful of unfamiliar buildings introduced into the famous New York City skyline by Illusion Arts lead painter Michael Wassel and artist Bob Scifo. One edifice, in particular, though—the imposing New York Public Library—is familiar even to Alex’s nineteenth century eyes.

Disembarking from the time machine, Alex decides to explore it. In lieu of filming the scene on location—an approach that would have put a strain on the already tight production budget—Price opted for an alternate solution. “Bill Taylor went to Manhattan and shot a still photograph of the library on medium-format 6x7-centimeter negative to use as a background plate,” explained Price. “That gave us a lot of room to create a post camera move. We could tilt up and down and pan left and right, because the image was so much larger than the final 2.35 film frame that would be extracted from it.”

It then fell to Price to shoot a matching foreground element of Alex climbing the library’s steps. “Bill had taken measurements of the library steps,” noted Price, “and we had the art department do a ‘back projection’ so that we could calculate additional distances and camera angles. Using the information we derived from the photograph, we built a set of stairs as a bluescreen set piece that matched those of the library for size and position.” The matte painting, the still photograph and several layers of bluescreen actors were combined by Illusion Arts lead compositor David Williams.

Inside the building, in place of a human librarian, Alex encounters a holographic projection called ‘Vox,’ which dispenses exposition while moving about inside a series of glass panels. Hoping to achieve Vox imagery in-camera, with minimal postproduction involvement, production shot the character in the simplest way possible. “Guy Pearce and Orlando Jones, the actor playing Vox, performed together across a suspended pane of real glass,” Price explained. “We then used roto mattes to remove any portion of Vox’s image that happened to stray beyond the boundaries of the glass rectangle as he gestured or walked from one pane to the next.”

Digital enhancements were mandated when Wells realized the character still needed something more to convey to audiences that Vox was not a physical entity, but merely an image in glass. “We started playing with some trailing, afterimage ideas,” noted Erik Nash, “but when we sent a test over to the studio for review, it got a ‘been there, done that’ reception. In their screening room, while the film was being rewound, however, Walter Parkes commented on how interesting the trail looked



Wind and water erosion carve the earth as the untended time machine carries Alex thousands of centuries into the future. The shots were part of an all-CG showcase sequence, designed and executed by Digital Domain, that depicted, in mere seconds, the passage of eons of time in geological terms. Artists used proprietary tools and an array of techniques to render richly detailed, virtual landscapes and infuse them with atmospheric effects, then animated them to reflect the violent upheaval.

when it was running in reverse— instead of trailing Vox, it preceded and anticipated his motion. Compositing supervisor Bryan Grill did more testing along those lines, which everyone loved, and that became the signature Vox look.”

Eager to learn more about the future, Alex returns to his machine, fires it up and proceeds further in time, only to be rocked by a violent shaking that jolts the time machine back to normal time, landing him in the year 2037— a world now under martial law due to seismic and political upheaval triggered by the cataclysmic destruction of the moon.

Live-action of the chaos resulting from the moon’s disintegration was filmed on the Universal backlot, with the practical effects crew simulating falling lunar debris by feeding pieces of charcoal, cork, balsa wood and fake glass through a standard ice chipper. Wind machines blew the lightweight, but lethal-looking debris at stuntmen doubling for the actors in the scene.

At one point, the script had called for a chunk of moon rock to take out the top of a high-rise, causing National Guardsmen to scatter and Alex to flee for his life. Planned long before the horrific events of September 11, the series of shots depicting the high-rise destruction was undertaken by Digital Domain, but then cut from the film. Substituted were Cinesite shots of cracks and fissures forming in the ground behind Alex as he races back to the time machine amidst sprays of practically filmed steam and fire.

To escape the catastrophic events surrounding him, Alex powers up the machine once again; but as he does so, seismic activity rocks the device, rendering him unconscious and unable to arrest his journey forward in time. Unattended, the machine races ahead, carrying Alex all the way to the year 802,701.

For this second time travel sequence, tremendous geological changes occur as the machine blasts into the far distant future. “The cracks in the ground vent fire that surrounds the time machine,” Price explained. “Moments later, the seismic activity subsides, leaving bare hints of the foundations of buildings. Next, a great sandstorm washes across the eroded remains of New York. The sandstorm ends and water appears, forming a river; then the river erodes, dropping out of frame to form a canyon. The lip of the canyon advances toward the time machine, threatening to engulf it before coming to rest. A new ice age occurs; and a glacier sweeps forward, enveloping the machine. When the glacier melts, light breaking through the ice awakens Alex, and he manages to stop the machine just as foliage and trees form, covering a barren valley.”

The showcase sequence, given to Digital Domain, would require shot after shot of pure CG— be it matte paintings or fully procedural 3D terrain— offering animators a chance to flex their technical muscles. “It’s stuff we’ve never seen before,” said Price. “We wanted to portray just how violent the earth actually is when you view it over a geological time scale— and how beautiful it can be, as well.”

The bulk of the CG background work fell into three categories— plants, weather and terrain. For the



When Alex regains control of the machine and brings it to a stop, he finds himself in a far- flung future world inhabited by descendants of men who have evolved into

plants, animators worked closely with software programmers at Side Effects, again drawing on the power of Houdini-based L-Systems to put a variety of vegetation on the screen. Into the mix they also added a package from a German software

gentle Eloi and savage Morlocks. The Eloi habitat, filmed on a ranch in Placerita Canyon, outside Los Angeles, featured a real foreground windmill, while background replicas were matte-painted by Kelvin McIlwain at Illusion Arts.

manufacturer, Greenworks, called Xfrog, used for growing secondary plants that did not need to be highly choreographed. To achieve the image complexity required, Nash and his team did iteration after iteration, compositing the renderings together in layers to build up dense, rich detail.

Novel rendering techniques included the utilization of ‘voxels.’ Analogous to pixels, voxels consist of a 3D array of data values that approximate the distribution of features within a given volume.

“We have a tool in-house that normally renders stuff like cloud volumes and particles using a voxel and simulation technique,” David Prescott noted. “It’s really good and really quick, and it allows us to do complex dynamic motion simulations. But we’ve been finding more and more uses for it. We actually used it for plants in this show, which may come as a surprise; but because our plants were four-dimensional— that is, they needed to be seen under extreme time-lapse conditions, with each frame purporting to take place over a long period of real-world time— we didn’t always need to render individual leaves. Instead, we employed voxels to sketch in just the volumes of the leaves in aggregate.”

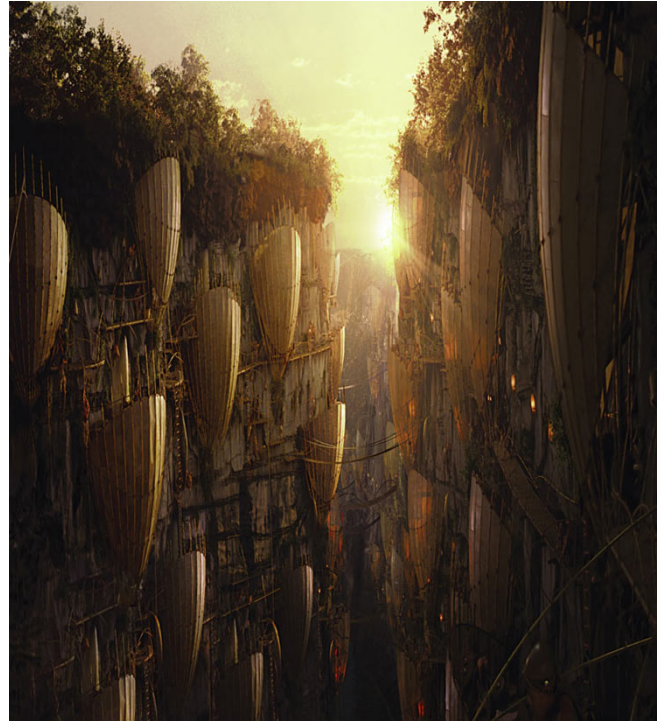
Also in the sequence were expanses of grass and scrub and pine trees, contributed by effects lead Sean Faden. “We originally considered shooting real plates and doing 2D gags on them,” Prescott related, “but the camera moves the director envisioned precluded that approach. To achieve the look of grass, Jason Iversen came up with a technique similar to those used to render hair and fur. To save on machine resources, we also had long strips of pre-rendered grass motion-blurred, swaying in the wind and mapped onto cards in the distance. Here again, the fact that our virtual shutter is open for days and days per frame would suggest that individual blades of grass shouldn’t be seen, but we allowed them to appear now and again to help the eye understand what it is seeing, so it can pull discreet, recognizable features out of what otherwise would have been just a mushy green blur.”

A great deal of effort went into rendering realistic landscapes, and then putting those digital environments into motion. “We came up with a hybrid approach,” said Prescott. “We used Terragen—an amazing tool written by Matt Fairclough that makes photorealistic landscapes very quickly—to generate arrays of terrain altitude data called ‘height field’ maps from selected canyons. Then Johnny Gibson and Chris Yang developed a second tool that allowed us to take these height fields and animate them in every way you could possibly imagine. We had control over the altitude, wind erosion, water erosion, the introduction of boulders and strata, sedimentation and water levels.” Ultimately, the burden of making the shots believable fell to the compositing team. “Bryan Grill and his people artfully blended the myriad 3D elements,” stated Nash, “created additional 2D elements and infused atmospheric and optical effects to reach a photoreal result.”

Regaining consciousness and halting the time machine in this unknown, far-future world, Alex is discovered by Mara (Samantha Mumba), a young Eloi, and taken to her village, nestled high on the walls of a steep gorge to protect its inhabitants from predatory Morlocks. Village exteriors were filmed on a series of elaborate sets designed by Oliver Scholl and built on a stage at Warner Brothers. An enormous cliff façade, seventy feet high by one hundred feet long, covered the entire length and height of the stage. Strung across it was a network of steel catwalks made to look like bamboo, with sail-like awnings and multilevel platforms marking the Eloi dwellings along the cliff face.

To supplement performers shot on the actual set, Price compiled a library of individuals photographed against greenscreen—on four-perf, full-aperture film—that could be used as needed to populate the cliffside huts. “Although we generally used those people small in frame,” recalled Price, “we decided to shoot them on film instead of digital video to preserve the possibility of using them large in frame if we so chose. For the set itself, we shot with Vistavision in order to give us the flexibility to add postproduction camera moves.”

Illusion Arts employed simple camera tricks to create establishing shots of the cliff set that extended the view. “The enormous set that Oliver Scholl built was absolutely beautiful,” noted Bill Taylor, “and there was a tremendous amount of coverage possible on it. But when they had to back off for establishing shots, they needed to see both sides of the valley and the chasm. Since we only had access to a wall representing one side of the rocky, V-shaped gorge, we approached these



To protect themselves from marauding Morlocks, the Eloi construct their dwellings on the steep sides of a rocky gorge. On a studio soundstage, production designer Oliver Scholl and his team erected an enormous cliff façade, strung with a network of steel catwalks and multilevel platforms accessed via hidden scaffolding. Though only one side of the chasm was built, Illusion Arts created establishing views showing both sides by shooting the set from opposite ends, with appropriate reversal of the stage lighting, and joining the combined imagery with matte paintings.

master shots by photographing the set from both ends and compositing them in post.” In order to make the incident lighting angle consistent on both sides of the gorge, camera crews moved all of the lights from one side of the set to the other between takes. As an added advantage, this approach allowed director of photography Don McAlpine to leave the lights in frame, as they could be removed during compositing.

Other Eloi settings— including several built at Sable Ranch in nearby Placerita Canyon— were also extended or enhanced with 2D and 3D elements. “It is always interesting to see how much Illusion Arts can accomplish with just 2D,” noted Jamie Price. “For example, sometimes the distant rivers were 2D with motion added through displacement maps so that you see just a hint of shimmer as the water recedes into depth.” Illusion Arts used Maya and LightWave to add 3D elements, as well. “There was one shot,” recalled *Bill Taylor*, “where Alex and Mara are paddling their canoe toward an Eloi settlement. We filmed it at the L.A. County Arboretum, in a canoe on a pond. We had originally intended to replace everything in the shot except the canoe and the water, but soon found that the reflections on the pond were obviously those of the arboretum, and not of the new backgrounds we created. Consequently, we had to replace most of the water, as well. We ended up lifting the couple and their boat out of the water with a soft matte, and putting them in a whole new digitally created environment.”



Portrayed for the most part by live performers, the misshapen Morlocks were the work of creature creators at Stan Winston Studio, who designed, fabricated and maintained an array of full-body prosthetics worn by both hero and background characters. Two basic body styles were required – wiry and athletic for the spy Morlocks and heavily muscled for the hunter Morlocks.

Alex's introduction to Mara's world is interrupted when the gentle Eloi are attacked by raging Morlocks, subterranean cave dwellers who emerge at dusk to hunt and capture the Eloi for their own dark purposes. The Morlocks come in two varieties—spies and hunters. The spies direct the hunt, singling out Eloi for capture by marking them with a dart. The hunters do the actual work of capturing the Eloi, trussing them up and dragging them underground. Mara is swept up in the hunt, prompting Alex to follow the mutants into their underground lair.

While the Eloi in *The Time Machine*'s distant future possessed a kind of nonspecific pan-racial beauty that could be achieved solely with costuming, the Morlocks displayed apelike characteristics that went beyond the scope of what casting and wardrobe alone could accomplish. The production strategy called for the mutants to be portrayed by actors in full-body prosthetics, with CG characters substituting for the live performers whenever more extreme movements were required.

To pin down a look for the Morlocks, Wells engaged the celebrated creature creators at Stan Winston Studio. Led by effects supervisor Greg Fiegel, Winston artists explored ideas on paper, then sculpted clay maquettes, which finalized or fleshed out what the drawings suggested. These were then cast into fourteen-inch-tall silicone figures that were painted and had hair implanted according to their design. Once the maquettes were approved, color schemes had to be determined. The maquettes were shot with a digital camera, and black-and-white images provided a starting point, or blank canvas, so that scores of color designs could be created by the Winston team, utilizing Wells' initial input as a springboard. Another helpful step in the process was to adapt the pure design of the first maquette to human form to avoid surprises during the process of making the full-size sculptures. "We cyberscanned our two main performers for the hunter and spy characters," stated Fiegel, "and from those scans, fourteen-inch-tall figures were made that our artists sculpted the Morlock designs over, to determine what, if any, were the compromises of translating the designs to a man in a suit."

Though early iterations included long, apelike arms and oversized hands, those gradually gave way to a look that was more in keeping with human proportions. Distinctions were made, however, between the two types of Morlocks represented in the story, with the slender spy Morlocks exhibiting a spidery agility and the hunter Morlocks possessing exaggerated body musculature. "All of the Morlock



Portrayed for the most part by live performers, the misshapen Morlocks were the work of creature creators at Stan Winston Studio, who designed, fabricated and maintained an array of full-body prosthetics worn by both hero and background characters. Two basic body styles were required – wiry and athletic for the spy Morlocks and heavily muscled for the hunter Morlocks.



suit performers did their own stunts,” said Figiel. “They were hired by stunt coordinator Jeff Imada and had to attend ‘Morlock school’ to learn the right body language for their characters.”

Once Wells had honed in on a look, Figiel and his crew began building the foam rubber Morlock muscle suits. Three hero suits were fashioned, while another twenty, less detailed versions were created to be worn by background players. Hero heads— two hunter versions and one spy version— were radio-controlled, driven by thirty-two servo motors housed within the head or in backpacks worn by the performer. On set, the suited actor was responsible for the overall body performance, while puppeteers operated facial expression— including eye, brow and mouth articulation. “The performer’s face inside did not match up with the Morlock face outside,” related Figiel, “so in order for the performer to see, small monitors were mounted in the helmet, which received a video signal from a tiny camera concealed in one of the nostrils of the Morlock face.” In addition to this, a fellow stuntman was posted just out of camera range as a spotter or guide for the performer in the suit. For running or stunt work, the performers wore lighter background/stunt heads, which had no servo motors and allowed better vision.

Stan Winston Studio character effects supervisor Greg Figiel fine-tunes one of the Morlock head sculptures prior to molding. Facial articulation on the hero heads was radio controlled, driven by servo motors concealed in backpacks worn by the actors and operated off-camera by Winston puppeteers. Lighter-weight background heads, which eliminated the servos and allowed for better vision from within, were created for running or stunt work.

Besides the normal daily maintenance involved in preserving a fragile foam rubber suit, some special on-set maintenance was called for during filming. Each hunter suit featured thousands of hand-punched, individual yak hairs which, due to constant wear and tear, needed to be continually maintained by an on-set hair department. A final touch was to cover the Morlocks with fuller’s earth and mud, suggestive of the characters’ underground environment.

The first rigorous activity imposed on the suited performers was the dramatic way in which they made their entrance. Each time a Morlock appeared on the scene, he did so by bursting up through the ground— a move engineered by the practical effects crew. “We made a bunch of ‘Morlock elevators’ at the Sable Ranch location,” explained Matt Sweeney. “We buried standard overseas shipping containers, twenty feet long with an eight-foot-square cross-section, under the ground. We used those because they were strong and safe and they kept the dirt out— we didn’t have to shore up the holes we dug. Inside the containers we rigged hydraulic lifts that could shoot the Morlock stuntmen up so that they burst through dirt-covered latex slits in the earth. After they cleared the hole, the performers would spread their legs to keep from falling back inside. The latex sealed the aperture beneath them, and the loose dirt camouflaged it.” Wire rigs were also employed to fly Morlock performers through the air, selling the illusion that they could leap in ways that defied gravity.

Stunt work and practical gags could only carry the human performers so far, however. When the Morlocks were running on all fours in full pursuit of the Eloi, Wells wanted them to display superhuman speed and agility. To realize such extremes of locomotion, seen in some seventeen shots, live performances were intercut with CG Morlocks created by Industrial Light & Magic.



For scenes of the Morlocks running on all fours in pursuit of the Eloi, live-action performers were replaced with computer generated doubles, provided by visual effects supervisor Scott Squires and his team at Industrial Light & Magic. Often juxtaposed and intercut with the Winston suits, the digital Morlocks closely matched their live counterparts, but were animated to suggest a cheetah-like speed and agility.

To ensure a good match, ILM visual effects supervisor Scott Squires began by having the Winston suits scanned at CyberWare as a guide for the CG modeling. To aid in the lighting and texturing, digital artists took reference photographs of a Morlock performer holding standardized gray and color cards. “We also had suited performers walk through a lit scene, whenever possible, to provide us with additional lighting reference,” said Squires. “What complicated matters was that our reference Morlocks were often filmed at the beginning of a sequence, and so were typically not as dirty as they would become after hair and makeup people altered them over the course of the shoot. Sometimes the guys in costumes had pomade and dirt in their hair, and matching that took a bit of doing.”

Animating the hair and clothing of the CG Morlocks to match their live-action counterparts proved particularly time-consuming. “The original Morlock designs had very little hair,” said Squires. “When that changed to long flowing hair, we had to alter our CG version of the Morlock, which required some changes to the ILM hair software. That aspect of the project was overseen by CG supervisor Carl Frederick. Costumes were made up of hanging pieces, which we dynamically simulated with our existing in-house software.”

To pin down essentials of the digital performance, Simon Wells worked closely with ILM animation director Tom Bertino. “I mainly worked long-distance with ILM,” explained Wells. “They sent down tapes for my review. We tried the satellite hookup thing, but I found it more frustrating than helpful because I could not control it as I could a videotape from this end. Since I am an animator myself, and have directed so much animation, it would have been useful to work face-to-face and act things out for them, but the schedule simply didn’t allow it. So Tom and I developed a shorthand way of communicating with each other.”

“Obviously, Simon had a more specific idea of what he wanted from the animation than the average director would have,” Bertino added. “He never said anything vague, like: ‘I don’t know, it just doesn’t look right.’ He often directed down to the level of a body part, enhancing the apparent weight of a character by adjusting, say, the wrist pose, or the timing of a pause.”

Wells based Morlock run cycles on cheetah locomotion, so details such as wrist flicks were especially important to get right. “The Morlocks were actually built more like apes than cheetahs,” said Bertino, “but for the ‘freakiness quotient,’ we wanted a catlike behavior, not an apelike one. Cheetahs do a lot of work with their spine— which is a lot more flexible than a biped spine— and these humanoids were designed to be muscle-bound around the shoulders and torso, which made it more difficult for us, at first, to give them a feline run. After a lot of experimentation, we were finally able to find the right combination of vertebral motion, shoulder roll and forward cheating of the hips to bring off the illusion.”

Live Morlocks were frequently intercut with digital ones within the same sequence, making it crucial that the two sync up perfectly. “We didn’t want a mismatch between them,” remarked Price. “We were always sure to overlap the range of motion the characters would exhibit in order to ease the transition between Stan’s work and ILM’s. The suit performers exaggerated their motion on set at the end of their takes, and the CG crew members began their shots with relatively normal, human-looking animation.”

In one notable case, the two approaches were combined in a single, continuous shot. “We started with a highly detailed, realistic closeup of a practical Morlock,” Price recalled, “but wanted to end the shot with actions that a guy in a rubber suit could never have done. We had a stunt performer start the shot by leaping into the air. We panned with him as he fell onto a visible safety mat, and the camera then followed an imaginary figure, as if he were running out of frame. We then shot a clean plate— clean, that is, except for survey tracking markers to be removed later— matching the previous camera move as best we could, by ‘feel.’ The clean plate became the ‘B’ side of the shot, and the basis for ILM’s animation. Then during a fast pan in which the Morlock is in focus, but the background is motion-blurred, we transitioned from one to the other. This gave us an intermediate plate, a seamless background with a Morlock popping offscreen halfway through.”



Penetrating the Morlock’s subterranean lair, Alex comes upon the über-Morlock (Jeremy Irons), the super-intelligent master of the mutant hordes. Makeup supervisor Greg Nicotero of KNB EFX Group devised a stark albino look to keep Irons recognizable and the character essentially human from the front, but with a surprise embellishment visible from the rear – an overdeveloped cerebellum that has split the über-Morlock’s skull and extended down his back. Lens technician Christina Patterson fits Irons with contact lenses to complete the mutant makeover.

ILM matched the stuntman with overlapping animation, using the live-action Morlock as lighting reference. “Greg Maloney, our compositing supervisor, combined the two plates with a lot of tracking and blending,” said Scott Squires. “Then our matchmover tracked the stunt performer, and our animators used that as a starting point for the digital character animation. The technical director was able to match the lighting and complete the transition with a few frame dissolves and a frame or two of paint.”

Following the raid, in which Mara is abducted, Alex pays another visit to Vox— still functioning amidst the ruins of the now-ancient library— and learns that the entryway to the subterranean Morlock world is through a ventilator shaft under a giant sphinx, the statuary emblem of Morlock society. Digital Domain resurrected its original Vox effect for the sequence, giving the character a dirtied, rougher look to suggest age and compositing him into footage of the crumbling edifice — an elaborate set built by the production. For shots of Alex climbing down the ventilator shaft, Digital Domain extended a practical set to make it appear deeper, and C.O.R.E. Digital provided a flock of CG bats that fly past during the descent.

In a great subterranean chamber, Alex encounters a super-intelligent ‘über-Morlock’ (Jeremy Irons) who controls all of the other Morlocks telepathically. “In the über-Morlock,” related Wells, “we had a character that didn’t exist in the novel or in the George Pal version of the tale. I had always wondered how these great honking pale guys with blue hair and bath towels knew how to operate all the machinery in their underground lair. I felt the need for some greater central intelligence in control of these monsters. What we came up with was a sort of community animal idea, like a beehive or an ant nest, where there are castes that are designed and bred for specific purposes. If the spy Morlocks are the eyes and ears of the system, and the hunter Morlocks are the muscle, then the über-Morlock is the brain behind it all.”



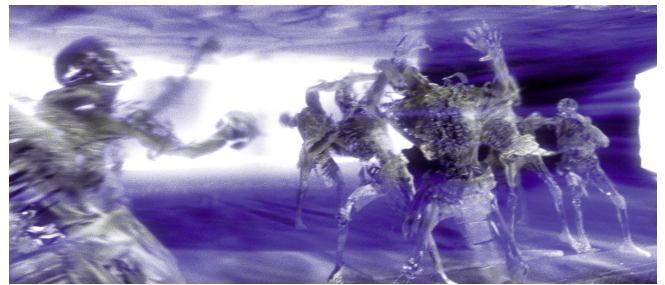
In the course of a struggle that ensues in the powered-up time machine, Alex pushes part of the über-Morlock’s body outside the machine’s protective sphere, exposing the mutant to grotesque accelerated aging as he comes in contact with a different temporal dimension. The Digital Domain team replaced Jeremy Irons with a digital double, projecting his visage onto the virtual geometry to use as a basis for building a full disintegration effect.

To create the character, the production approached KNB EFX Group. The phone call, from producer David Valdes, was an especially exciting one for KNB partner Greg Nicotero. “David knew that I was a huge fan of the original Time Machine,” recalled Nicotero, “and that I had built an exact replica of the original machine in my house. I was dying to work on the project.” Valdes gave KNB a month to prepare and plan an approach. Once shooting began, Nicotero knew his crew would have to work fast, due to Jeremy Irons’ limited availability. “Production said we would have Jeremy for six days, and that would be it. We had to squeeze the entire sequence into that one short period.” Initial testing by production makeup department head John Elliott served as a takeoff point for the KNB work. “John did some tests using a sort of albino look— white skin and a white wig with a widow’s peak. Bob Greenwood’s design for the costume exposed a lot of Jeremy’s skin, so not only did we have to devise makeup that would cover him from the waist up, it had to be able to withstand a

twelve-hour day without rubbing off. The production was intent upon keeping Jeremy recognizable — but because his voice is so distinct, they allowed us to add soft contact lenses to further alter his appearance. We proposed yellow wolf eyes and bloodshot eyes, but finally settled on albino white ones.”

Since Wells had intended the über-Morlock to serve as the central intelligence of the Morlock society, he directed KNB to add a surprise element to the makeup, designed to drive the point home. “The character looks elegant from the front,” stated Nicotero, “but when he spins around, you see that his cerebellum has grown into a massive organ which has forced his skull open, split his shoulder blades apart and is growing down his back. The ‘brain bag’ was this whole prosthetic piece with bladders in it, because they wanted it to pulsate and move. We designed the spine to move with it in a way that was as anatomically correct as is possible for such an unnatural thing.”

Nicotero, together with makeup artists Chris Nelson and Jake Garber, added a membrane covering the brain so that the über-Morlock would appear less vulnerable to physical attack. “Without it, anyone could just walk up and stab him there,” Nicotero noted. “It really didn’t make any sense for his brain to be totally unprotected, especially if he is supposed to be super- intelligent. So we covered it with silicone and embedded yarn in it to simulate veins. Then we added a silk organza that we soaked in KY Jelly to make it sheer and gross-looking. We did several versions to make sure it looked like a convoluted brain, and not intestines.”



An explosion of temporal energy emitted from the time machine destroys the vast network of subterranean tunnels and disintegrates the Morlocks trapped within. Shots of the destruction, involving both live-action and CG Morlocks, called for a coordinated effort between Industrial Light & Magic and Stan Winston Studio, with Digital Domain providing the final, unifying look.

The telepathic über-Morlock recognizes Alex for what he really is— a traveler from the distant past who has stumbled into this strange new world. The two fall into hand-to-hand combat in the still-powered-up time machine, and their struggle continues as the activated machine commences time traveling and the chamber walls dissolve. At one point during the battle, the time machine’s center of gravity shifts and it rolls over— a trick accomplished by rotating the machine on a special yoke built by the Sweeney team.

To give Wells the most flexibility, Price suggested that the sequence be done as a series of greenscreen composites, offering the director the latitude to shoot the fight as he wished, without regard for the feasibility of capturing appropriate backgrounds for each camera angle. Digital Domain would then supply the missing background imagery from a virtual set.

“For many years,” stated digital effects supervisor Jonathan Egstad, “we’ve been digitally stitching separate photos together into one large background plate, so we can do nodal moves— pans and tilts— in virtual camera space. This pan-and-tile technique allows us to reduce the load on the 3D department by moving some of the work into 2D that would normally be done in 3D. In this case, however, instead of using pan-and-tile, we rented a Panoscan camera to get the surrounding virtual texture maps. We textured those panoramas onto the inside of a virtual sphere or cylinder and rendered out flat tiles that were then passed to our compositing department.” Use of the technique

did present some drawbacks— cost being but one of them. “The Panoscan output was typically not used raw— we had to clean it up a bit. That’s one reason we didn’t make it our primary form of image capture. The other was that it’s slow. In order to get high resolution out of it, we had to shoot with long exposure times, which slowed us down and prevented us from capturing motion.”

When Alex pushes his adversary outside of the protective time sphere that surrounds the machine, the über-Morlock’s body is vaulted into a different temporal dimension where it is subjected to a grotesquely rapid and unevenly distributed aging process before disintegrating altogether. For the scene, Digital Domain replaced Jeremy Irons with a computer generated version of the actor. The initial transition between the two was achieved by tracking the virtual camera to the live-action one and aligning the real actor with his CG counterpart. “Once the two lined up,” commented David Prescott, “we were able to replace Jeremy by camera-projecting his virtual image onto his virtual geometry, which gave us a basis on which to build the computer generated disintegration effect.”



A giant sphinx, the emblem of Morlock society and entrance to the underground world, dominates the future landscape in a Cinesite establishing shot. The disintegration and collapse of the sphinx at the film’s conclusion was originally captured photographically by the Digital Domain stage crew, using a large-scale miniature shot high-speed. Following a late redesign of both the sphinx and the final sequence, however, Cinesite was called upon to reaccomplish the destruction digitally.

To appease the MPAA ratings board, Wells had set forth guidelines for the über-Morlock’s demise, directing Erik Nash to minimize the gore by making it a dry mummification-type process. The character team, led by Brad Parker, used Maya for modeling, skinning and texturing the CG character, then exported that work to Houdini for the final disintegration. “As this guy mummifies and melts away,” said Prescott, “his clothes rust and erode and his skin turns to beef jerky. He becomes more and more skeletal, and finally his head falls off and his bones crack and crumble to dust. We got rid of the skin fairly quickly over the course of three shots and passed rapidly through a sinewy internal stage— which culminated in his reduction into dust. For the falling, tumbling, colliding bones, we used Maya’s dynamic rigid body simulation system.”

Having vanquished the über-Morlock, Alex gains control of the time machine and halts its forward progression. In this unknown future, the machine is now perched on a ledge overlooking a ravaged rocky landscape dominated by Morlock sphinxes and a yawning pit where Eloi are being driven down into the bowels of the earth by their Morlock oppressors. The hellish setting, topped by a roiling blood-red sky, represented a radical departure from the one originally conceived by production in which the future is revealed as a paradise devoid of Morlocks. Assigned to the scene, Illusion Arts had done considerable work on the original concept, combining live and digital elements with a large-scale matte painting of the utopian landscape. “It was a big conceptual change in the story,” recalled Jamie Price, “but the studio was concerned that the idea of paradise was confusing, since people were asking, ‘Why does Alex need to go back?’ So they changed the concept entirely, making the future a Morlock-dominated world— which reinforced the idea that Alex has to go back to finish off the rest of the Morlocks.”

The revised sequence—executed by Illusion Arts, with the exception of two or three lead-in shots by Digital Domain of the cave eroding—featured an all-new matte painting by Kelvin McIlvain, combined with 3D sphinxes, CG characters and practical fire elements. The previously filmed foreground view of Alex standing in the time machine was digitally altered to reflect a new camera move, and color timing was adjusted on several of the lead-in shots to take their color more towards the hellish tones established in the painting.

Having glimpsed the bleak Eloi future, Alex powers up the time machine and returns to the über-Morlock's subterranean lair. To preclude further time travel, he places his pocket watch in the gears of the time machine to jam it. However, the action causes the machine to malfunction, releasing an explosion of temporal energy that surges through the subterranean world, destroying the caverns and reducing the Morlocks to dust.

With several vendors contributing to the finale, Jamie Price called upon Digital Domain to tie it all together and provide a unified look. "We wanted Digital Domain to do the timewave," Price commented, "because they were doing so many of the other procedural disintegration effects, and because it needed to match the luminous effects animation they had created for the time machine itself. We also had a number of shots with both live-action Morlocks and CG Morlocks destroyed by the time energy wave. We wanted the disintegration to be the same, regardless of whether the Morlock was Stan's or ILM's; so it made sense for Digital Domain to do it for both."

In creating the timewave, paraphernalia lead Rob Frick and his crew built on the look of the transitional time bubble animation established earlier. "We used a simple piece of CG geometry onto which we attached various shaders that evoked a bit of the smoking, undulating feeling of an aurora borealis," explained David Prescott. "We used no volumetric rendering for this animation; we didn't even use particles. Everything was achieved through the use of hard geometry and soft-looking shaders. Simon had asked us not to conceal the audience's view of the erosion of the walls and Morlocks, so we avoided creating too dense and obscuring a volume."

Since the Morlock caverns had consisted primarily of an elaborate set, Digital Domain needed a 3D representation of that set for interacting with the timewave. "We did a lot of re-projecting photography onto matching or loosely matching geometry," Prescott noted. "The technique was useful for allowing us to erode the cave walls."

Given the extensive utilization of CG Morlock animation in the scene, ILM needed a 3D representation of the set, as well. "The tunnels began with fairly level floors," observed Scott Squires, "but their designs evolved over time to the point where they became quite irregular. This gave us some work to do, because our characters' footfalls and their cast shadows had to land on those irregular surfaces. We took a number of pictures and used in-house software developed by Steve Sullivan to do photo-modeling of these surfaces. Conveniently, most of the pictures we needed for this we could pull directly from different frames of the moving background plates."

ILM also had to match the CG Morlocks to interactive elements shot on set. "When the CG Morlocks ran," stated Squires, "they often kicked up live-action leaves or jostled bamboo stalks that were rigged to scatter. In the caves, they dislodged a lot of dust that we had shot over both black- and bluescreen." To complicate matters further, there were moving cameras. "On the cavern set, the

cameraman was often sitting in a chair suspended by swinging wires, or operating a low-angle Steadicam-like unit we called the ‘doggy-cam.’ In one case, the camera was mounted on an all-terrain vehicle, which gave it a pretty bumpy ride. To work under those conditions, one of our matchmovers used a transit system to measure and survey the sets. We also placed markers on set to help us track.”

Shots of the Morlock hordes fleeing on all fours as the timewave engulfs them were achieved through a collaborative effort on the part of ILM and Digital Domain. “Almost every shot in the sequence had ILM CG Morlocks,” Price observed, “but as the time energy destroys them, Digital Domain took over. To do this, Digital Domain would scan the plates, track them and send the data to ILM. ILM would then animate to the Digital Domain camera.”

A pipeline set up at Digital Domain allowed data to flow in both directions, while ensuring that neither company would trample on the other’s proprietary methodologies. “ILM supplied us with multiple passes of their rendered CG character work,” recalled Jonathan Egstad. “We received key light passes, fill passes, interactive lighting passes and fur passes. Going the other way, we replaced greenscreens with shaft or cave extensions and supplied the plates in Cineon format to ILM so that they could use them as backgrounds on which to place their character animation.” Using its EXR floating-point imaging format to retain the full dynamic range of the images, ILM output its work back to Cineon for delivery to Digital Domain.

In a wide aerial shot— combining Illusion Arts matte paintings and Cinesite effects animation— the serpentine network of glowing Morlock tunnels collapses, as Alex and Mara narrowly escape the destruction. To reinforce the point that the Morlocks are dead, Wells called for the Morlock sphinx to decay into rubble. Charged with producing the effect, Erik Nash and Digital Domain opted for a practical approach, using a large model of the structure. After viewing the sequence in the context of the film, however, Wells decided to make some adjustments to the appearance of the sphinx and the manner in which it disintegrated.

With the postproduction clock ticking and Digital Domain fully engaged in other work on the film, Price took the redesigned sequence to visual effects supervisor Tom Smith at Cinesite, opting instead for a digital solution. “Jonathan Gerber modeled the new sphinx based on drawings provided by production,” observed Smith, “John Hewett went to work creating the metal surfaces to match the practical references, and compositing supervisor David Rey took charge of integrating it into the environments. The sphinx ended up looking much more menacing, with a recognizable feline structure.”

Instead of the sphinx’s collapsing, the reimagined sequence had the timewave energy blasting up from underground to cause a rapid erosion. “A violent, blue-white beam of light shoots up through the sphinx, causing it to burn away— not by fire, but because it’s aging so rapidly,” explained CG supervisor Serge Sretschinsky. “It just rusts away. Then there’s a punctuating beat where the remains float away like the last bit of burning embers.” To preserve the original notion of choreography, which emphasized the sphinx’s facial features, Sretschinsky’s department devised a special-purpose tool that allowed Wells to creatively guide the progress of the corrosion using a CG model of the sphinx.

In the final destruction sequence above ground, a vast network of Morlock sphinxes and pathways was depicted by effects art director Lubo Hristov using matte paintings derived from plate photography filmed in Hawaii. A combination of different effects animation suggested the collapsing fissures of escaping time energy welling up from beneath. “There’s an incredible amount going on in that end sequence,” noted Smith, “almost to the point where it’s difficult to see it all.”

There were, doubtless, moments during the production of *The Time Machine* when Simon Wells, a novice director juggling the demands of a technically complex, high-stakes Hollywood film, must have wished for a time machine of his own. In the waning days of principal photography on the show, Wells had been forced to take a hiatus due to exhaustion, and Gore Verbinski had stepped in to complete the filming. “The toughest thing, for me, was doing the actual physical shooting,” Wells admitted, “because I’d had very little experience with that. I had to learn on the job; and, frankly, I just worked myself into the ground. Looking back over the whole thing, if I could have done it differently, it would have been really nice to have had an extra three months of preparation time.”

In spite of the setback, Wells recovered in time to direct postproduction and see the project through to its completion, remaining ever resolute in his vision for the film. “I must say that I had the ambition to make sure that this was a quality production with an intelligence behind it,” Wells noted, “and not just a sort of slam-bam action adventure with lots of stuff blowing up. That said, it is a slam-bam action adventure with lots of stuff blowing up— but it’s also a film with intelligent, philosophical, emotional themes that play throughout. While I didn’t feel pressure to adhere slavishly to the original book, I did feel the pressure within myself to create an entertaining and worthwhile film— and I’m proud of the end result.”

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Under Fire

ARTICLE BY JOE FORDHAM

When Mark Bowden's book, *Black Hawk Down*, appeared in 1999 and was lauded by literary critics and military historians as one of the best ever written about infantry combat, Hollywood, not surprisingly, took notice. Written in a terse, novelistic style, *Black Hawk Down* expanded upon a series of articles Bowden had originally compiled for The Philadelphia Inquirer, interweaving multiple eyewitness reports of a 1993 United States military operation in Mogadishu, Somalia, that went grievously awry. Though documented extensively by news media at the time, the bloody one-day conflict quickly faded from public consciousness, despite the loss of nineteen American servicemen and hundreds of Somalis.

Producer Jerry Bruckheimer— many of whose movies have involved military themes— acquired the rights to the Bowden account in 1997. Allied with Revolution Studios and Sony Pictures Entertainment, he then attracted the interest of director Ridley Scott— on a career high after his Oscar-laden *Gladiator*— and commissioned screenwriter Ken Nolan to adapt the story. Nolan's screenplay, given final shape by Steven Zaillian, began by sketching in the political backdrop to the Mogadishu mission with an opening sequence in which U.S. Army soldiers— part of a United Nations peacekeeping force— witness rebel militiamen, in the service of warlord Mohamed Farrah Aidid, subjugating starving Somalis by withholding famine relief. Seen through the eyes of rookie Ranger Sergeant Matt Eversmann (Josh Hartnett) and cohorts, the film depicts the efforts of seventy-five Ranger infantry and forty Delta Force troops to curb Aidid's terror tactics by abducting his top lieutenants in a coordinated air and ground assault. From Sikorsky UH-60 Black Hawk helicopters, the Army elite fast-rope down into a rebel stronghold in the city— but the mission goes bad from the moment they hit the ground as thousands of Aidid militiamen and supporters respond in fury to the incursion. When rocket-propelled grenades fell two of the Black Hawks providing cover fire, Ranger and Delta forces try to retrieve the downed pilots, only to find



For *Black Hawk Down*, the cinematic reenactment of a disastrous 1993 United States military action in Mogadishu, Somalia, director Ridley Scott relied heavily on practical effects, orchestrated by special effects supervisor Neil Corbould, to create the film's harrowing combat sequences, though a wealth of digital work was provided in post by Mill Film and Asylum Visual Effects. Mill Film created an early shot of the U.S. task force embarking on its fateful mission. The composite featured a matte painting of a distant air base and multiple passes of two live-action helicopters – one Black Hawk and one Little Bird – layered in to increase their number.



Little Birds fly over the streets of Mogadishu. In a show of support for the project, the Department of Defense provided four Little Bird and four Black Hawk helicopters, as well as tanks and other Army hardware – all employed within Mogadishu lookalike sets built by production designer Arthur Max in Morocco. Though the Corbould

themselves hemmed in by enemy fire for fifteen hours while their commanding officer, General William Garrison (Sam Shepard), scrambles to mount a rescue.

team produced volumes of real smoke on location – in keeping with the in-camera style of the film – a more dramatic look was achieved in postproduction with the addition of CG smoke. Asylum produced black smoke columns through a mixture of volumetric 3D and 2D particles.

Early on in the project, Bruckheimer gathered key members of Ridley Scott's most recent production staff, among them executive producer Branko Lustig, production designer Arthur Max and editor Pietro Scalia. Lustig, in turn, secured the services of additional *Gladiator* alumni, including London visual effects company Mill Film, special effects supervisor Neil Corbould, stunt coordinator Phil Neilson and armorer Simon Atherton. Asylum Visual Effects, a longtime Bruckheimer collaborator, joined the project during postproduction.

In addition to this sterling support crew, Bruckheimer and Scott sought one more collaborator: the Department of Defense. Despite the uncompromising and frequently grim nature of Bowden's book, the U.S. Army had embraced it due to the veracity of its account of modern combat from a soldier's point of view. To secure military support, Bruckheimer commissioned production illustrator Sylvain Despretz to create a series of large-format line drawings depicting the battle as it would appear on screen. "We showed them these illustrations of the men fast-roping in," said Jerry Bruckheimer, "and gave them a little dog-and-pony show that helped everyone to see how we felt about the book. They got very excited."

The first challenge facing the production was to find a workable location. Although seven years had passed since the events, continued unrest in Somalia made shooting in Mogadishu unfeasible. "We weren't allowed even to scout the country," said Arthur Max. "We were told that just to enter Somalia, we'd need at least a twenty-person armed bodyguard; and even then we wouldn't have been able to trust that security, because there were so many rebel factions. It was not safe—anywhere." Scott and Max dismissed the alternative of reconstructing Mogadishu on a studio backlot. "We knew we were going to have so many aerial views of helicopters flying over the city in turmoil, no matter how much we built, it would not have been enough. So our plan was to find an existing city that was a lookalike for Mogadishu, and build into it."

After studying news photography of the event and the environment, Max and Scott finally selected Rabat, the capital of Morocco, in northwest Africa. "Morocco was the closest, culturally, to Somalia," stated Max. "When you see Mogadishu from the air, there is a rugged coastline with seventeenth-century colonial fortifications; and Rabat has the same— even though, in Mogadishu, the colonial influence was Portuguese and Italian, and in Rabat, it was French and Spanish. Both cities were overlaid with Arabic and Muslim architecture. In fact, some of the aerial photographs that we present in the film as Mogadishu are actually Rabat printed backwards, the Atlantic Ocean flipped to stand in for the Indian Ocean."

Rabat and neighboring Sidi Moussa, Salé and Kenitra offered locations for the story's target area, the outlying city and the U.S. Army base, respectively. With the endorsement of the king of Morocco, King Mohammed VI, Scott and the art department laid out their plans to re-create war-torn Mogadishu. "We surrounded ourselves with the living city," related Max, "turning Rabat's soccer field into our target build-ing site and marketplace. We also rented a number of partially completed

buildings, which there were a lot of. The local people would often build as much as they could afford, then go off to make more money before returning. For our army base, we took over a disused Royal Moroccan Air Force base outside Ken-itra, which was built in the sixties by American troops who used a prefabricated military pattern identical to the Ranger barracks in Mogadishu. When they allowed us to put up a tent city on their aircraft taxi area, we had a perfect double of the Somali base.”

Morocco proved accommodating in other respects, as well. Maureen Quinn, the chargé d'affaires for the U.S. Embassy in Morocco, negotiated with the Pentagon and representatives of the Senate Armed Services Committee to allow for the presence of the Army on the production. “It was not easy,” noted Max, “because at the time there was some political unrest in the Middle East, and large groups of American armed forces arriving in Morocco with all of their support equipment and ground troops was not your every-day event.” In addition to military personnel, twelve U.S. Army Humvees, twelve Tyssen Condor armored personnel carriers, six Army trucks and several Abrams M1A2 tanks were allocated to the shoot, along with four Black Hawks and four Hughes MH-6 Little Bird helicopters.

The hard reality at the heart of the film influenced every aspect of it, from the screenplay to the production design to the visual and physical effects. In Ridley Scott's first meeting with Mill Film visual effects supervisor Tim Burke and visual effects producer Emma Norton, he informed them of his intention to go for a gritty, in-camera look, relying on physical effects as much as possible, with digital effects used only to enhance environments, combat and helicopter action. On point for those was Neil Corbould, whose company, Neil Corbould Special Effects, is located at Pinewood Studios in England.

In addition to his work on *Gladiator*, Corbould had previously simulated combat for *Saving Private Ryan*, collaborating with his brothers, Ian and Paul, who themselves had later created prosthetic and floor effects under Joss Williams for the television miniseries, *Band of Brothers*. A first read of the *Black Hawk Down* screenplay, however, challenged all the Corboulds' previous experience. “It was just



The mission goes awry as one of the Rangers jumps from the Black Hawk, misses the rope and falls sixty feet to the ground. Mill Film rotoscoped a falling stuntman from the location plate, added CG dust, debris and ground plane, then reinserted the live performer, executing a morph to a fully CG character upon impact.



The mission goes awry as one of the Rangers jumps from the Black Hawk, misses the rope and falls sixty feet to the ground. Mill Film rotoscoped a falling stuntman from the location plate, added CG dust, debris and ground plane,

nonstop,” Neil Corbould stated. “Usually, when I break a script down, I highlight the physical effects.

In this case, I might as well have painted the whole

script with a highlight pen! After the first third of the story, every line was effects, effects, effects.”

To spread the work-load, Neil Corbould made the project a family affair, placing brother Ian in charge of a nine-person crew that applied prosthetics and blood hits on location, with John Schoonraad managing prosthetics production at Pinewood before joining the shoot. Paul Corbould supervised a twenty-person crew that handled first-unit pyrotechnics and atmospheric effects, while Andrew Williams supervised second-unit floor effects. Neil Corbould’s production manager and sister, Gail Corbould, oversaw operations at Pinewood, and his father, Cliff Corbould, joined him in Morocco to act as physical effects buyer. Before shipping out to Africa, the entire Corbould team spent three months developing pyrotechnic, prosthetic and mechanical effects dictated by the script, simultaneously stockpiling generic effects to support the eighteen-week shoot to follow.

then reinserted the live performer, executing a morph to a fully CG character upon impact.



Somali rebel forces attack the incoming helicopters with rocket-propelled grenades, downing one of the Black Hawks. The initial hit was achieved by combining live helicopter footage with a Mill Film computer generated RPG and practical fire and smoke elements. Also created was particle-animation smoke emerging from the shattered tail of the aircraft.

Members of the physical and visual effects teams arrived in Morocco prior to filming to review the locations and sets built by Arthur Max and his multinational crew during a twelve-week construction period. In Sidi Moussa, the production erected the target building as a four-story set capable of taking the weight of a 1.75-ton Little Bird landing on its roof, and selected a wide swathe of Rabat to represent sites where the Rangers set down, each of which had to be retrofitted to withstand military assaults. "A big part of our operation was rooftop dressing to prepare for low-flying helicopter rotor wash," explained Max. "Set dressers and construction crews spent months securing all of the rooftops for twenty square blocks around the target building area, lashing down all the Moroccan inhabitants' bric-a-brac, which never seemed to end."

As sets were prepared on location, Sylvain Des-pretz continued storyboarding action sequences with Ridley Scott, who produced his own pen-and-ink sketches, called 'Ridleygrams,' and delineated which areas and structures would be destroyed once bullets began to fly. Final storyboarded action called for long strafing runs across existing architecture, which required special preparation of the structures by the effects and construction crews. "These were peoples' homes," Corbould observed, "so we couldn't drill into the walls to place our detonators for bullet hits. Instead, we devised a way of cladding the real walls with 'biscuit foam,' which is a brittle urethane material. We got it down to a fine art. We took molds of the existing walls, then construction battened-off the walls with one-by-twos, extending sometimes two hundred yards down the street. Next we built a big steel press, laid sheets of quarter-inch plywood in the press, poured our biscuit foam mixture over that, clamped it down, and out would pop two-inch-thick, four-by-eight-foot sheets of bullet-hit wall."

Construction also mixed soda ash with plaster and pigment to create ten thousand lightweight destruct-ible gray bricks, molded to the size of a loaf of bread and used for patching holes in dummy walls and dressing into existing architecture. Use of the fake bricks reduced the risk of actors being injured by fly-ing masonry as bullets shattered buildings. Construc-tion also utilized the soda bricks to build and insert entire walls into structural frameworks, rigged by the effects crew to collapse on cue with pneumatic rams and pyrotechnic charges.



For a shot of the crippled Black Hawk striking the top of a building during its downward plunge, Mill Film added a CG helicopter and impact debris to a clean live-action plate.



A four-corner intersection around a public fountain where Eversmann and his team took refuge, an area known to the Rangers as ‘the Alamo,’ suffered the brunt of the destruction. That location was built from the ground up in Sidi Moussa. “*The Alamo* started out as a partially constructed housing estate,” noted Arthur Max. “It was quite isolated, and some of the buildings were only half completed. We finished off the façades, built a variety of interiors, and fabricated entire buildings with huge holes blown in the roofs as if they had been gutted and destroyed.”

For the pivotal helicopter crash, which was slated to be achieved practically, Neil Corbould and his crew suspended a lightweight Black Hawk shell from a sled and cable array attached to a construction crane and anchored near the ground. Upon its release, the mockup slid rapidly down the cables, swooping over rooftops and striking a breakaway fountain before being released from its sled and impacting heavily in a city square set built on location.

Principal photography started March 8, 2001, setting the tone with an intense fusillade of pyrotechnics in Sidi Moussa. “We had our three military advisors— all veterans of the actual assault — sitting in the video room next to Ridley,” recalled Neil Corbould. “Ridley gave the word for the cameras to turn over, and then said, ‘Action!’ For five minutes there were rockets flying down the streets, sides of buildings blowing out, bullet hits flying everywhere, people falling down. When Ridley shouted ‘Cut!,’ our advisors were absolutely white. They said: ‘That was it. We were back there again.’”

Throughout the shoot, Corbould’s team equipped first and second units with custom supplies to facilitate the speedy simulation of vast amounts of fire-power. Floor effects preparation at Pinewood had included assembling and shipping that pyrotechnic arsenal. “We had been granted one permission to ship our pyrotechnics into Morocco,” observed Paul Corbould, “so all the armaments and ammo had to arrive in one go. Simon Atherton and I had done quite a bit of research for *Band of Brothers*, so we knew what detonators we tended to use the most— ST-78s for AK-47 and M-16 ‘pings,’ and ST-100s for chunkier .50 caliber hits. We estimated the number we’d need, then doubled it, just in case. Our whole shipment included about 86,000 individual charges.”

Among the pyrotechnic supplies were custom striker boards, streamlined versions of traditional pyrotechnic nail boards— detonators triggered by a solenoid, or nail, brushing past individual wires, which lead to individual charges. By pre-assembling strings of detonators in looms, the Corbould striker boards allowed vast quantities of detonators to be plugged together in a modular fashion. “If we had to run out a loom two hundred feet,” explained Neil Corbould, “we could take four looms of fifty feet and just click them together. In the old days, we would have had to run each wire two hundred feet to the nail board.”

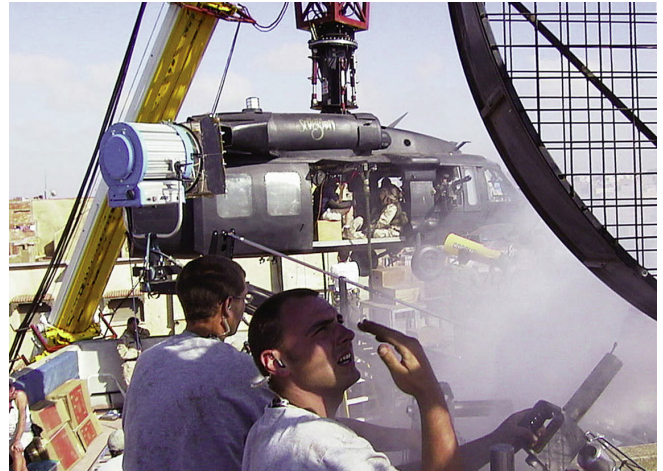
For larger bullet hits, Paul Corbould’s team planted detonators in cork blocks. After setting the charges in place and sealing them with dirt or plaster, they laid wires across road surfaces to off-camera switches and striker boards. Set dressers then concealed the wires with debris. On busy days, Scott covered master shots with multiple camera setups, often requiring up to 1200 bullet hits per take. For heavier explosions simulating mortar hits and grenades, the effects team placed charges inside cylindrical steel sleeves that vectored the blast away from actors. “Safety was always our first concern,” remarked Paul Corbould, “so we made sure explosions went straight up. After we buried the steel pot in the road and placed the charge, we packed it with lightweight material, mostly peat and cork, making sure we didn’t pick up any rocks or stones that might hurt somebody.

Then one person would watch that bang. Each guy who had a striker knew the location of every one of his charges. If anyone came near it, he wouldn't let it off."

Floor effects technicians used a combination of pyrotechnic and mechanical techniques to simulate the impact of a twenty-millimeter shell on a Somali 'technical'—one of an array of revamped Toyota pick-up trucks and chopped down minibuses designed by the art department and outfitted with guns by Simon Atherton. "There were three stuntmen and a dummy in the technical," noted Paul Corbould. "We fitted a pneumatic ram inside, which was like a piston operated by high-pressure nitrogen, and rigged a string of twelve small charges underneath. The ram kicked the technical up in the air as the charges went off in rapid sequence. The explosions overlapped, extending the blast while keeping down the heat."

One sequence that typified the pyrotechnic chaos in the streets involved a convoy of Humvees, originally positioned to provide a fast evacuation of prisoners, but eventually lost in hails of enemy machine-gun fire. As stunt drivers navigated the maze of narrow streets, their vehicles were riddled with hundreds of bullet hits. "I knew it was going to be very difficult to hide one of our effects operators inside the Hum-vees to let off all those hits," observed Neil Corbould. "Swinging around at thirty or forty miles an hour, anyone inside the truck could easily get bashed and let bullet hits off by accident. So we decided to trigger the detonators with radio-controlled sequencer boxes. We put eight charges on a strip, and then pressed a button to make them sequence through a firing pattern. We fitted sequencer boxes inside the Humvees, rigged these to strips of seven hundred bullet hits inside each vehicle, then took very high-end radio control equipment and tuned it to our firing boxes. When we started the shot, one operator armed the radio control; then, as soon as we were underway, the operator hit the button any time we wanted bullet hits to go off."

To enhance the visual barrage, Paul Corbould introduced Ridley Scott's signature smoke and haze to director of photography Slawomir Idziak's cinematography. "The Somalis were always burning tires as signal fires in Mogadishu," stated Paul Corbould, "but when tires burn they leave a lot of residue, and it would have been a real problem to have done that in the middle of Rabat." To generate more manageable thick black plumes, the effects team utilized a heavyweight industry-standard smoke machine known as a Danté. "We pumped diesel oil into the Danté through hydraulic hoses at very high pressure. The hoses led to a jet that atomized the fuel at a pilot light, which burnt it off as thick black smoke. The heat made the smoke rise; and when the helicopters flew through, they created these interesting atmospheric effects that Ridley loved." The team produced less noxious 'pea-souper' smoke effects using truck-mounted Aerodyne Bedler smoke machines. Fueled by two



For scenes impossible to obtain with real military helicopters, Ridley Scott utilized two Corbould-built Black Hawk mockups on location to capture close and medium shots of his actors aboard and flying the aircraft. Corbould 'flew' the rotor-less mockups by suspending them from a motion controlled crane arm capable of ascending to sixty feet and performing a range of maneuvers. Asylum tracked digital rotor blades and interactive light flicker to the Black Hawk replicas in postproduction.

forty-five gallon drums of refined paraffin mineral oil, the Bedler filled the cargo area of a four-wheel drive pickup and was capable of being operated in motion.

In postproduction, Mill Film generated giant columns of digital black smoke to reinforce the practical atmospherics created on set. “The live smoke effects were pretty spectacular,” Tim Burke observed, “but for a few sequences, CG technical director Alex Rothwell generated smoke stacks using Maya particles. He produced some very balletic effects, where the choppers flew through the columns and created these incredible swirls.” Similar effects were produced at Asylum by CG artist Gunther Schatz. Drawing on his experience supplying smoke and tracer fire for *Pearl Harbor*, and referencing footage of burning oil wells from the documentary *The Fires of Kuwait*, Schatz constructed billowing smoke columns by building stacks of 3D particle emitters. For distant shots, *Inferno* artists composited smoke clouds in 2D, layering them behind buildings. For closer views, CG artists created 3D collision objects where smoke was seen to coil over buildings.

Streaking through the haze were rocket-propelled grenades, or ‘RPGs.’ “There were a lot of discussions early on about whether we should do the RPGs for real or with CG,” said Neil Corbould. “Paul and I did some tests in England with a two-pound urethane foam rocket running on bearings down a piano wire, going left to right. We took a twelve-millimeter-thick sheet of clear polycarbonate, attached our wire to that, lined a camera up behind the polycarbonate, and stood a stuntman in front of it to hide the wire. We then shot an RPG straight at our guy, so the RPG was coming right at camera. When we showed that to Ridley, he jumped out of his seat. He couldn’t figure out how we’d done it. Once he saw that, it was RPGs everywhere!”

The Corbould team used about sixty such rockets in the film, many of which were improvised and rigged with little warning. “One day while we were shooting,” Ian Corbould recalled, “Ridley said that he wanted to do a whip pan with an RPG and see it hit a soldier. It was a very quick effect, but the rocket had to fire about a hundred yards before hitting this guy. So we very quickly rigged a line, rigged a dummy with explosives, flew the RPG down the wire and set the dummy off when it hit. The dummy was in the middle of a group of stuntmen, so it was quite intricate.” Mill Film and Asylum handled RPG-wire removal and digital enhancements where physical effects were not possible, the former producing digital RPGs to show ground-to-air missiles striking Black Hawks and for scenes in which closeup rocket backblasts flared directly into camera.

One of the most ambitious RPG effects was for a sequence in which a Somali rocket impales a moving Humvee, fatally injuring the driver, U.S. Ranger Private Richard Kowalewski (Brendan Sexton), known to his comrades as ‘Alphabet.’ Shot as second unit, the effect was supervised on set by Andrew Williams and employed a specially rigged Humvee to receive a wire-flown RPG in its driver’s door. “We pre-drilled the Humvee door,” recalled Paul Corbould, “then we fitted it with a steel pot, called a ‘catcher,’ so the RPG wouldn’t pierce the vehicle—the catcher caught it as it hit. We then rigged a charge inside the vehicle to send dust and debris flying, simulating the RPG coming out the other side.”

To trigger pyrotechnics in time with the impact of the onrushing missile, Ian Corbould donned a Ranger uniform and occupied the forward passenger seat. “Ridley wanted to see the RPG coming toward us before it hit,” Ian Corbould observed, “and those things moved bloody quick! I worked out when the Humvee, traveling at thirty miles per hour, would coincide with the RPG being shot at

it down an alley. We fitted Brendan Sexton with a kevlar corset with a big hit on his side, then they set the cameras up pointing through the truck. When we got up to speed, the pyro boys let the RPG go, the rocket hit the catcher pan and I hit a button that triggered three explosions in quick succession— outside, inside and on Brendan, spraying blood up the window between him and the door.” Mill Film completed the scene in postproduction, generating a digital model of the RPG, tracking it to the shot and puncturing both the door and the driver for a few horrific frames. Mercifully, at least for Alphabet’s comrades, the RPG fails to explode and is later glimpsed imbedded in the Ranger’s torso.

The extreme realism of the battle dictated that the physical effects crew simulate armament hits on many other characters, as well. One of the most versatile effects was a blood-mortar device first devised by the Corbould team for *Saving Private Ryan*. “We took a flexible steel tube and fed this into a steel cartridge,” stated Ian Corbould. “We placed a detonator in the cartridge, then filled the cartridge with stage blood. When we fired the detonator, the expansion emptied out the tube of blood on the actor. I had always worked with eighth-inch-diameter tubes, but Ridley asked if we could try one-inch, which created great hose-piping effects. He asked us to alter the pressure, too, using different size detonators. As always, safety was paramount, but we experimented until we got the effect that he desired.” The flexibility of the firing tubes enabled Corbould’s crew to strap the rigs to actors on a moment’s notice, creating shocking explosions of blood across exposed areas of flesh without the need for traditional prosthetic squib applications.

John Schoonraad’s makeup team also created prosthetic effects for a scene in which Ranger Corporal Jaime Smith (Charlie Hofheimer) undergoes field surgery after a bullet hits him in the upper leg and severs his femoral artery. Prosthetic artists fabricated a medically accurate leg for the scene, detailed with realistic flesh and subcutaneous layers, and attached it to the actor, whose real leg was hidden beneath a cut-away tabletop. Prosthetic work was also featured in scenes at a Red Cross tent at the U.S. Army base where medics struggle with the life-and-death after-effects of the assault. To fill out the scene, the makeup crew manufactured hundreds of specific and generic prosthetics in gelatin, and generated three hundred articulated silicone dummies to serve as fallen combatants. Silicone dummies representing emaciated Somali famine victims seen in the opening title sequence were also provided.



The helicopter clips a fountain just prior to impact. When the practical crash photography did not cut in well with preceding live-action footage of a real spinning helicopter, Mill Film digital artists replaced much of the physical effect with a sequence of shots employing their CG Black Hawk, complete with CG crew inside. The background was

A series of tiled images reassembled in postproduction with the camera move applied. Subsequent shots in the sequence featured a digital reconstruction of the location set to facilitate interaction between the environment and the CG Black Hawk. Composited with a background live action plate and a foreground miniature. Practical dust and debris were produced by a sixth-scale miniature helicopter with functioning rotor blades. The animation file from the CG helicopter was plugged into a custom-built modelmover to create appropriate movement in the helicopter model. The half-scale foreground miniature was shot bluescreen, with a pyro-rigged chair timed to break apart when hit by a piece of CG shrapnel.

While the re-creation of the human casualties was perhaps the most disturbing aspect of the production, the greatest technical challenge was simulating the action of the Black Hawk and Little Bird helicopters. Although the U.S. government had committed to providing the production with real helicopters, they did not arrive until quite late. “The problem was getting them into Morocco,” said Jerry Bruckheimer, “and negotiations between our production, the State Department and the Moroccan government really became bogged down. Rid-ley wanted them on the first day of filming, but we didn’t get them until almost the fifth week.”

As a backup, in case the real aircraft were never allowed into the country, Neil Corbould instigated a miniature strategy that required substantial research and development. “*Dave Hunter* headed up the build-ing of three sixth-scale flying helicopters at my Pine-wood workshop,” Neil Corbould recalled. “Our initial plan was to use these as foreground miniatures if we couldn’t get the real thing. We bought the engine from a company in Florida that specialized in radio-controlled crop dusters. Since most radio-controlled miniature helicopters have two blades, this company modified a souped-up lawn-mower engine to take four blades, emulating the Black Hawk.” Even when the real Black Hawks became available, Corbould considered that the ten-foot-long models— used in combination with full-size and computer generated helicopters to keep the audience guessing— might be useful for a major crash sequence. “We even had a British champion radio-control helicopter pilot with us on location. But in the end, we didn’t use them. They just sat in the box.”

Another contingency plan was to employ Hueys as Black Hawk stand-ins. “It was getting real close,” remarked Bruckheimer, “so, for backup, we secured some Hueys from Germany. We were going to paint them black and digitally augment them to make them look like Black Hawks.”

When the full-scale Black Hawks and Little Birds finally arrived, they were supervised on set by aerial coordinators and camera pilots Marc Wolff and David Paris, who worked with aerial director



A rocket-propelled grenade streaks through the war-ravaged streets of Mogadishu. In addition to sixty practical RPGs created by the Corbould crew – which ran urethane foam mockups down piano wire – Mill Film animated digital versions for shots of the aerial weapons striking targets or rocketing toward camera. Both Mill Film and Asylum performed wire removals for shots featuring the practical RPGs.

of photography John Marzano and the team of military pilots for four weeks on location— an anxiously awaited portion of the shoot. “We tested with our Huey camera ships before shooting the major helicopter assaults,” Arthur Max recalled, “but the pilots told us that these were nothing compared to what we were going to get with the Black Hawks!” Indeed, the Hueys were dwarfed by the eight-ton, sixty-four-foot-long Sikorsky UH-60s, capable of carrying up to twenty troops and external loads of up to four tons.

Nevertheless, the fortified rooftops and set constructions withstood the Black Hawk’s fierce rotor wash, and the Rabat Fire Department controlled unwanted street-level turbulence by hosing down dusty road surfaces. But controlled, aesthetically pleasing effects of the rotor downdraft in the arid streets became a visual motif for the movie. “Ridley felt quite strongly that dust would play an important role in the story,” said Tim Burke. “When the helicopters landed at the beginning of the raid, the downdraft from their rotors created an intense, blinding dust storm that separated the Rangers. We discussed how we should work with those dust effects on set, whether we should subdue live dust then simulate it digitally in postproduction, or try to shoot it all in-camera. We decided we felt more comfortable adding it later so Ridley could shoot what he needed and not end up with footage of dust and nothing else.”

To lay the groundwork for the postproduction simulation of dust roiling through Mogadishu streets, Mill Film lead technical director Olcun Tan joined Burke and Emma Norton on location for six weeks, bringing with him a tachymeter to map helicopter crash sites, the target building and other locations. Used in architectural surveying, the tachymeter is a laser-calibrated instrument, similar to a theodolite, employed for measuring distance, direction and elevation. Modifications to the device enabled Tan to survey landscape topographies and load the data directly into Maya, creating 3D environment simulations. “Olcun’s setup was certainly the most successful surveying technique we’ve used,” Burke stated. “It enabled us to take a lot of wild plates and aerial scenes, some shot with Wescam, some even hand-held, and match and track CG elements to anything we were given.”

3D artists Alex Rothwell and Joseph Pepper, working with senior digital compositor Richard Roberts, led the generation of omnipresent dust, combining live elements with digital volumetric particle animation. The effect was called into play early in the mission, when Ranger Private First Class Todd Blackburn (Orlando Bloom), a member of Eversmann’s team, becomes the first casualty of war. As the Rangers fast-rope in, Blackburn jumps out of the Black Hawk, misses the rope and drops sixty feet to the ground. Eversmann descends next, and rushes to his fallen comrade. Ridley Scott circled the two men in a 360-degree camera move, and Mill Film added a CG dust environment around them. “Ridley shot the scene in front of the target building with no dust,” Burke remarked. “It was quite a complex Steadicam move spiraling around Eversmann and Blackburn. We hand-tracked the shot using our on-set survey data, then completely filled the environment with atmospheric debris, so Eversmann appeared to be lost in this world of dust.”

During a blackscreen Vistavision shoot at Sheperton, Burke dropped fuller’s earth, grit and dust in front of an air mover on stage, shooting dust blowing from behind camera, in front of camera, into camera and from the side. Digital compositor Peter Marin combined these elements in Flame, using the 3D camera move tracked from the set survey data to tile and overlap the Vistavision plates in perspective, then enhanced this with Maya particle animation and digital flotsam. “Joseph Pepper

developed a CG debris generator,” related Burke, “creating a series of plastic bags, newspaper and pieces of rubbish in Maya. We rotoscoped Eversmann and Blackburn to separate them from the background, then matted them in amongst our blowing dust, using the roto mattes as collision objects to displace the 3D particles.”

Final composites would feature live helicopters flying through the particle animation dust, often performing hair-raising maneuvers, including formation-flying at street level and erratic moves to simulate receiving enemy fire. However, the immense power of the real Black Hawks on location thwarted some of Scott’s storyboarded plans. “We couldn’t fly Black Hawks behind certain buildings or at certain heights,” recalled Sylvain Despretz. “Some seemed like simple shots: for example, we might have a Somali technical driving past a building, and as you look up you see the chopper right behind the building, zipping past. But although it was a beautiful composition and seemingly simple, it was just too dangerous for the Army pilots to fly their choppers so low and close to buildings.”

Tim Burke proposed a 2D solution. Working with second-unit director Alexander Witt, Burke set up a camera on a cliff overlooking the ocean near one of the shooting locations. At seventy feet above sea level, the vantage point afforded clear blue skies with low horizons against which the helicopter pilots could fly, swoop, spin and pitch their aircraft before a locked-off camera. Burke then shot handheld background plates on set, zipping past buildings and tilting up to empty areas of sky, checking his framing via instant video-assist digital composites of the backgrounds and the helicopter shots. Final composites of the helicopters and the background plates were done in Inferno in London.

To allow Ridley Scott to capture in-camera shots of actors flying in helicopters over combat zones, the Corbould workshop crafted full-scale Black Hawk replicas for use on location. “We decided that a lot of the angles looking out of the helicopter door, and where the soldiers fast-rope out onto the street, should be live,” stated Ridley Scott. “All the dialogue scenes inside the chopper were either done on the ground with CGI rotor flicker, or we shot them in the air, with a helicopter carcass on a giant crane, so I could look out the door and save myself some money on bluescreen. Bluescreen is always a nightmare, anyway, because you can’t really light a scene the way you want to; and adding the bluescreen area afterwards is always a bit of a palaver.”

The mechanical helicopter rig utilized a design Neil Corbould had developed previously for *Vertical Limit*, for which he had suspended a replica helicopter from a motion-controlled crane, allowing the aircraft to perform natural pitch, yaw and roll. The only snag facing Corbould as he drew up construction plans in early November 2000 was that the eleven-million-dollar Sikorsky UH-60 was a



Asylum provided digital Little Birds for a nighttime sequence in which U.S. forces attempt to drop supplies to their stranded troops. The CG Little Birds were modeled and animated in Maya, and had fully articulated pilots and guns, and a complete pitch rotor head to accurately simulate the features of the real aircraft. Asylum also created CG tracers, extrapolating their look and movement from military documentary footage.

classified piece of military equipment and, consequently, accurate reference material was scarce. “We started with absolutely nothing,” said Corbould. “We couldn’t get drawings or blueprints, so we had to figure out how we were going to build these two, all-singing, all-dancing helicopters, full-size, interior and exterior, from scratch.” Corbould initiated construction by purchasing a low-polygon digital Black Hawk model from Viewpoint and an Airfix construction kit. “We scanned the plastic model, overlaid it with the CG model and compared the two to make sure the dimensions were correct. We then scaled up that 3D model, sliced the fuselage into cross-sectional profiles, a foot apart, and printed out the profiles using our large-format printer. We pasted the profiles onto three-quarter-inch plywood, cut them out, and reassembled them to make our fifty-seven-foot-long fuselage, bolting the pieces together like ribs or bulkheads in the same way that shipbuilders put together sailing ships.”

Corbould technicians finished the wooden Black Hawk in three weeks, laminating bulkheads and detailing the surface based on photo reference. To speed production, Corbould subcontracted David Ford at Effects Associates—Corbould’s alma mater, now Cinesite’s physical effects company on the Pinewood lot—to mold, cast and finish fiberglass shells from the wooden plug and fabricate interiors, the latter task complicated by a lack of visual reference. Meanwhile, Corbould mechanical designer David Brighton crafted a metal framework to fit inside the shells and reinforce the structure.

The Black Hawk replicas each weighed two and a half tons and were bolted through the cabin roof to a 160-ton motion control crane for use on location in Sidi Moussa. Connected by a 650-foot umbilical that ran down the jib of the crane to a hydraulic motor and motion control computer, the helicopter was put through live and preprogrammed moves by an operator at ground level. The craft could ascend to sixty feet, hover, pivot, spin and swing in an arc while carrying actors and crew, who wore safety harnesses at all times as effects crew members buffeted them with air movers. Digital rotor blades completed the illusion of flight for views out of the doors and windows, and exterior closeups. “We modeled the Black Hawk rotor blades and rotor shaft from documentary and live-action reference,” said Nathan McGuinness, senior visual effects supervisor and founder of Asylum. “We painted out the crane in Inferno, tracked the blades and rotor shaft onto the top of the helicopter body, added interactive lighting to strobe across the helicopter, and gave all the shots subtle camera shake.”

Some of the helicopter action was too hazardous and dynamic to be realized by either the real aircraft or the motion-base replica. For such shots, Mill Film 3D artist Paul Amer built digital Black Hawk models using Alias Wavefront Power Animator. Amer relied upon a variety of reference sources, including a PDF of a workshop manual bought at an Internet auction site, photographs from the Internet, a hobbyist’s manual on helicopters and Tim Burke’s on-set photographs. “The model was accurate, inside and out,” noted Burke, “and could take off and land as a real helicopter



Ridley Scott replicated the fury of the nocturnal assault by filming the real helicopters simulating a full-out strafing run on a two-city-block area of the location set. Huge numbers of pyrotechnic hits, attached to custom striker boards developed by the Corbould team, were wired into the buildings and street. Some 86,000 individual charges were expended in the course of principal photography. Asylum later enhanced the scale of the live-action attack, adding CG tracer fire, as well as quarter-scale to sixteenth-scale smoke and explosion elements.

would, with the rotor blade RPM and pitch all correctly mimicking the real thing. It was constantly being updated, with more and more detail added as the production required our CG helicopter to play a more significant role.”

Asylum created 3D Little Birds for some of their more dynamic scenes, starting with a commercially available digital model from Viewpoint. 3D artist Eric Lee modified and textured that basic model from photo reference, paying special attention to four-way gun turret movement. In one of ten shots featuring the CG Little Bird—a wide-angle down-view through the blades of two Little Birds flying one above the other as Somalis flee below—a Huey first hovered in the shot as a lighting reference stand-in. That lower Huey then departed to allow an upper camera craft to capture a clean background plate. Lee positioned digital Little Birds per Scott’s Ridleygram, and gauged digital blade rotation, paint reflection and cockpit canopy translucency from the Huey stand-in.

Digital and physical helicopters both played a role in the defining moment of the film, when the Black Hawk flown by Chief Warrant Officer Cliff Wolcott (Jeremy Piven) takes a rocket-propelled grenade in its tail and spirals to a crash. “I think any good effects director will always ask, ‘Can you not shoot it live?’” stated Ridley Scott. “If you try to shoot a live effect and it doesn’t work, you’ve always got a wonderful benchmark, which you can add to later. We couldn’t take a real Black Hawk and crash it, so I knew there would be a moment where we’d leave the real helicopter and go to the digital helicopter, then return to the carcass of a real helicopter. That was always a given. So Neil Corbould’s team rigged the carcass of a full-size chopper on cables to hit the top of the building, crash into the fountain in the square, hit the ground, and then slew under the volition of its blades. We thought we’d be able to use most of that, but it eventually became easier for Mill Film to use that as guidance.”

The Corbould practical crash rig consisted of a pair of 820-foot cables strung from the 160-ton crane into the Alamo set. A replica Black Hawk on a skate was suspended between the cables. When released, the mockup slid under its own weight and plummeted toward the fountain at the center of the square. The length of the run proved too dangerous using the two weighty mockups, so Corbould commissioned Effects Associates to build a third, lighter Black Hawk shell in three weeks, dressed with sufficient detail to withstand scrutiny during the rapid descent.

Eight cameras covered the effect, three buried in the ground at the final impact point. When Corbould technicians released the helicopter, it swooped low over rooftops, struck the top of a building, traveled another four hundred feet, crashed into the break-away fountain, then dropped from its sled. Following the crash, Tim Burke filmed clean plates of the set, duplicating camera



United Nations forces harbor injured troops in a makeshift fieldhospital, hastily set up within a Mogadishu soccer stadium. When no suitable stadiums could be found in the immediate location area, the filmmakers elected to shoot at a partially constructed arena and realize the remainder of the stadium as a digital set, built by Mill Film. An aerial view of the stadium incorporated CG helicopters, vehicles and people, all added to a live-action plate featuring only a few live vehicles and performers.

positions and shooting back-ground textures to enable compositors to perform wire and rig removal during postproduction. As additional backup, Burke duplicated camera tilts and pans, approximating live-action camera moves by hand, and also shot nodal pans around the set, rotating a camera about a fixed point to gather back-ground tiles.

Final assembly of the scene was influenced by a dramatic piece of reference footage, discovered by Mill Film, that caught Ridley Scott's attention during preproduction. "There was a crash at an air show of a big chopper—I think it was a Sikorsky Sea Dragon—and it impressed the hell out of me," Scott noted. "First of all, it impressed me because everyone survived; but, secondly, because the blades kept going. They were lashing the concrete, like a huge eggbeater, and the blades were disintegrating, but were driving the body of this big Sea Dragon around like a dying cockroach. We used that as an idea when our Black Hawk hits the ground. Its blades dig in; so as they're lashing the dirt, they're shattering into shrapnel, at the same time turning the helicopter around until it comes to rest." Mill Film stabilized the handheld video footage and used it as the basis for an animatic of the crash.

For the start of the scene, a live spinning Black Hawk was filmed over the Moroccan coast. Alexander Witt provided the background plates by strapping himself into a Little Bird flown by a military pilot and ascending above Rabat with two cameras—one affixed to the helicopter, one perilously handheld. Mill Film animators later generated a digital RPG to hit the Black Hawk, added real fire and practical smoke elements, then matted and loosely tracked elements to the background in *Inferno*. Additionally, 3D artist Kieron Helsdon used Discreet's 3DS Max particle generator to create smoke coming from the damaged tail in subsequent shots involving the live helicopter after it has been struck by the RPG.

When Burke joined Scott and Pietro Scalia at their Santa Monica cutting room to review the edited crash sequence, it became clear that the live footage of the real spinning helicopter did not cut in well with the last few moments of impact captured by the physical effects team. It had simply been impossible to create a spinning effect with the helicopter sliding down a wire. "Neil had done a huge amount of work staging that effect," related Burke, "but we decided that we couldn't rely on those shots alone. So I went back to London to see if we could come up with something to convince Ridley that we could make the sequence work using our CG helicopter." Referencing the Sea Dragon crash, Burke produced a series of 3D-Maya animatics, animated by CG supervisor Laurent Hugueniot, using clean-plate backgrounds and animating the Black Hawk to spin, then crash and claw at the ground in front of a café in the Alamo set. Scalia cut the animation as if it were new dailies from the set, resulting in a montage of nine fully digital helicopter shots and three 'crash camera' cuts of the practical impact. Scott bought off on the animation, and Mill Film set to work realizing the shots.



A high-resolution digital matte painting of the stadium exterior extended a practical entryway and adjacent wall. The final Mill Film composite also included CG tanks, lights, smoke and dust, with live-action characters layered into the foreground. Near the end of the film, survivors of the misbegotten mission would reach the sanctuary on foot, captured in a seventeen-second Steadicam shot with a computer generated stadium matchmoved into position.

Paul Amer increased detailing of the CG Black Hawk to withstand dramatic closeups, while digital artist Gavin Baxter built and textured CG crewmen to occupy the cockpit. Olcun Tan also developed a dynamic system in Maya for breaking 3D rotor blades that allowed them to churn up digital particles and shatter against the ground, sending broken blade fragments flying into camera. Tim Burke meanwhile prepared a practical element shoot at the Mill Film motion control stage at Shepperton Studios, shoot-ing dust and debris to interact within the composite. “It was CG in reverse,” explained Burke. “We already had our animation, we now wanted practical elements to work with that. Our miniature effects supervisor, Adam Howarth, created a sixth-scale helicopter with a motion-controlled rotor and a series of rotor blades, some of which would shatter, some of which would stay together and dig through dust and dirt. All of this was driven by the animation from our CG, which we plugged into a custom-built model mover that was constructed to replicate all the different axes of rotation.”

Using the mold from Neil Corbould’s miniature Black Hawk, Howarth’s team constructed a ten-foot Black Hawk shell and sprayed the surface matte black. Modelmakers mounted the miniature to the model mover through a raised platform, then dressed the platform with sand and fuller’s earth. Burke set up three shots of the helicopter crashing and churning through the dirt. Using a Beaucam, a high-speed Vistavision camera, he also photographed dust and dirt cascading over the miniature. 2D artists then extracted dirt from shots by luminance-keying and garbage-matting around the ground.

Compositors assembled the digital Black Hawk crash shots in Inferno, making extensive use of Olcun Tan’s set surveys and Maya rotor blade dynamics. Michael Illingworth composited the first three shots in which the helicopter hit the ground, painting out the full-scale practical model and adding the digital model with crew members as the aircraft impacted the fountain and spun away. Grant Connor compos-ited a pan as the tail rotor swept by camera, animat-ing the move across a digital reconstruction of the Alamo set, built by tiling images from Burke’s safety plates. Peter Joplin composited the chopper’s final death throes as it shuddered to a halt outside the café, also adding a foreground half-scale miniature café set and chair. In the course of the shot, the chair is destroyed by a piece of rotor blade, created on the miniature by firing a scaled piece of blade and trig-gering a detonator to shatter the chair upon impact. Mill Film completed the sequence, from revised concept to final execution, in four weeks.

Later in the mission, a second Black Hawk, flown by Chief Warrant Officer Mike Durant (Ron Eldard), is also felled, with the crash glimpsed as a spy-plane video image in General Garrison’s joint operations center. Mill Film animated the CG chopper impacting the live street, and during postproduction improvised a further angle with the digital Black Hawk descending over the street. “We sneaked in a shot where you saw the helicopter from the ground,” stated Burke. “As Durant’s helicopter lowered to the ground, it generated a twister dust effect underneath. We created all the dust with Maya particles, practical elements and CG; so, as the helicopter approached, this tornado of dust moved with it, ripping tin roofs off the houses, which were all 3D, and throwing them at camera. It was quite spectacular.”

Enthusiastic studio response to an early screening of the picture, which prompted Sony to advance its release from March 2002 to December 2001— positioning it for Academy Award consideration—

shortened the postproduction schedule by two months, leaving Mill Film only eight weeks in which to complete 106 visual effects shots. This accelerated schedule led to the participation of Asylum, which tackled 104 additional effects in Los Angeles.

Asylum digital animation included *Inferno* sessions with Ridley Scott to increase the fury of a nocturnal Little Bird blitzkrieg when U.S. forces attempt to drop supplies to their stranded troops.

“Ridley had filmed the Little Birds strafing two city blocks as far as safety had allowed,” said visual effects supervisor David Jones. “We endeavored to take that footage and imagine, digitally, what it would have looked like had there been no concern for human safety. We also experimented with creating different ‘flavors’ of combat. Ridley felt that tracer fire in previous films looked too much like *Star Wars* laser beams. He described the effect he wanted as ‘electric pink worms wiggling at hyperspeed toward their target.’ We played around with a number of ideas, then Ridley brought in a tape of a Russian military test of machine guns panning and shooting tracers at landscape and livestock. It was very bizarre, and the tracers had a random ‘vibey’ look.” Asylum artists imported the video to *Inferno*, steadied and match-moved the imagery, and accumulated a variety of tracer effects, which they could then replicate from any angle.

During the Little Bird raid, both Asylum and Mill Film generated night-vision images to simulate the Ranger rescue team’s ground-level views. The effects companies also produced forward-looking infrared electro-optical displays on board the helicopter as it swept over the city, revealing heat signatures of militia advancing over rooftops. For ground-level shots, Tim Burke photographed Somali performers in Morocco, day for night. For aerial views, Mill Film used nocturnal Wescam plates and tracked in glowing fires and animated motion capture characters, using the characters’ mattes as heat signatures. Asylum completed work on the shots. “There is nothing exaggerated about the effects in this film,” asserted Nathan McGuinness. “We made the night vision look exactly as it looks in real life. You’re looking at a video screen with heat sensors, so anything warm appears to glow and fires are very bright. We also animated little strobes that the Americans throw when they see a helicopter in the air— these pulse with infrared light that only pilots wearing special glasses can see, so they can tell who are the good guys.”

Mill Film postproduction enhancements included digital crowd manipulation— sometimes removing, but more frequently adding live crowd elements in *Inferno*, sampling production plates of extras in Morocco. “We had a thousand extras on set in Morocco on certain days,” said Tim Burke. “While we were filming the raid, for instance, they had extras stacked up in a street to create a dense crowd. But as soon as we cut to an aerial view, that crowd looked quite sparse.” In addition to cloning live crowd elements for such scenes, Mill Film bolstered crowds with computer generated extras. With Laurent Hu-gueniot, CG artists Gavin Baxter and Joseph Pepper developed crowd flocking systems, built partially from textures of performers on location and partially from an existing library of motion capture data. Baxter and Pepper tracked motion capture Somalis running through the streets, and generated even larger throngs for an opening scene at the United Nations food distribution center, filmed on a hillside outside Salé where Arthur Max and his crews erected huts around an existing building. Olcun Tan surveyed the hillside, allowing Mill Film to add thousands of digital Somalis converging in a mass.

Mill Film also created digital set extensions for a panoramic view of the U.S. military base, seen as the task force embarks on its fateful mission, overflying a young Somali boy with a cell phone who is spying on the operation. Working from a Ridleygram, Tim Burke photographed elements at the Kenitra stand-in air base and at alternate locations overlooking a stretch of ocean and a hillside. Live helicopter elements posed a problem. “Unfortunately, the scene had been relegated to late in the schedule,” recalled Burke, “and by then production had to let two of the Black Hawks and two of the Little Birds go. And two of the remaining helicopters had mechanical problems. As a result, we had to film our shot of this great armada leaving the base using only one Black Hawk and one Little Bird.”

Burke photographed the two helicopters from different perspectives, performing repeat passes. To guide assembly of the shot, Sylvain Despretz returned to the production for a second round of storyboard-ing and generated a pencil-and-ink rendering of the finished scene using a Photoshop print of coastline background plates. Back at Mill Film, David Early generated a digital matte painting of the installation derived from the Kenitra plate, adding foreground runways, CG helicopters, CG Rangers and CG Humvees. Richard Roberts then composited the shot. “Richard tracked and matted eight different plates of helicopters,” explained Burke, “offsetting their movements a bit and matching them together. In hindsight, we realized that the helicopters would never have been able to fly so close together had we filmed them all at once, so by doing it this way we were able to give the shot more drama.”

Mill Film also generated the most expansive digital set in the movie — the Mogadishu soccer stadium seen in the final act, where United Nations forces set up a field hospital behind barricades to harbor injured troops. A viable location for the stadium eluded all scouting in Morocco. “The only stadiums we could find that were suitable were in Casablanca, forty miles south of Rabat,” stated Arthur Max. “This would have required a company move— with lost days, packing, transportation, re-housing the crew— which was very inconvenient. Also, if we had chosen the stadium in Casablanca, we would have been limited as to what we could shoot, since a local soccer team played there on a regular basis.” Rabat did have a soccer stadium of its own— albeit a largely unfinished one. “The stadium, which was actually in Salé, had just the bare bones of construction, but it offered unrestricted access because it had been abandoned. Eventually, Tim Burke and Mill Film helped us re-create the Casablanca stadium in Salé.”

To determine the extent of practical and digital set extensions needed in Salé, the art department took photographic studies of the stadiums in Casablanca and Salé and drafted technical drawings to compare arenas. Burke, Emma Norton and Olcun Tan meanwhile took reference of their own in Salé, and spent two days surveying with the tachymeter. That data became the basis for a Maya 3D model built by Frederic Durand at Mill Film. Arthur Max and Sylvain Despretz assimilated all of the visual material and generated conceptual art of the imaginary stadium. Max then overlaid printouts of early Mill Film wire-frames with tracing paper and sketched in color studies; Despretz created Photoshop renderings illustrating scale with debris and detail. These designs were fed back into the pipeline at Mill Film. While Scott roughed out action with Ridleygrams, Max laid out the construction department brief. “We smashed through a concrete wall and built a full-sized gate off the existing road,” said Max. “In CG, we built three more bleachers surrounding the playing field and

added CG buildings and a mosque in the background, retaining the same aged and derelict look for everything that we had in the rest of the film.”

Prior to the stadium shoot, property master Graham Purdy built forty-two tracking markers for Tim Burke to position around the set. Resembling Belisha beacons— British pedestrian crossing markers — the illuminated fluorescent orange balls atop black-and-white poles were placed at two different heights, spaced eleven and a half feet apart, providing compositors with reference with which they could align CG structures day or night, from any angle. Survey data and the profusion of visible references allowed Burke to avoid shooting blue-screen and greenscreen separations of actors in the stadium arena— rotoscoping characters instead in Discreet’s Combustion and Puffin Designs’ Commotion— and negated the need for on-set previsualization. “The Mogadishu stadium played much more of a background role than the Colosseum had in *Gladiator*,” Burke observed. “We were quite clear about how high our virtual structure would be because we had an existing wall extending about a quarter of the height of our CG set to guide us. When we were framing shots of the exterior, we could quite easily estimate where the top would be.”

Digital set dressing in and around the CG stadium included Arabic graffiti mapped directly from Burke’s Moroccan photo reference and matte-painted construction detritus. Digital tanks, armored personnel carriers and Humvees were customized from commercially available Viewpoint models, adding to the vehicles supplied by the U.S. Army. Duran modeled, textured and lit the CG stadium structure itself by simulating the radiosity technique used to light the *Gladiator* Colosseum— computing bounce light, fill and key light, then blending three passes, this time in a single pass in Maya.

The climax of the film featured the stadium in a complex reveal that began with the survivors of Eversmann’s team running through early morning mist toward a shadowy shape looming in the distance. In one unbroken Steadicam shot, the camera then unveiled the stadium using a transition improvised in postproduction. Photographed initially as Eversmann’s point of view as he passes crowds of cheering Somalis, the running shot contained rows of lampposts lining the street and several distant buildings. By hand-tracking lampposts and buildings in Flame, Mill Film carried the Steadicam move into a 4K digital matte painting of the exterior of the stadium, composited with live cheering people, CG tanks and barbed wire barriers. “We hand-matted and layered a lot of the foreground characters,” Tim Burke explained, “then we generated layers of CG mist and added those on top. The mist slowly opens and reveals the stadium at the last minute, as if the sun were burning the mist away. Then, as the camera stops, soldiers run past it toward the stadium, which you finally see in bright sunlight. It’s the first time in the film the audience have any sense that Eversmann and his men are safe and they’ve made it home, so it’s quite a dramatic moment— and quite a long shot, lasting seventeen seconds.”

The movie ends on a somber note, rather than one of triumph— Eversmann acknowledging a battle hard fought while infantrymen head back into the city to search for the bodies of two fallen comrades. Beyond subtitled summations that impart the facts behind the mission, no further statement is made. “Although *Black Hawk Down* is clearly an anti-war movie,” observed Ridley Scott, “it is also pro-Army. I wanted to put the audience in the front seat so they were with these soldiers

all the time. If the result is harrowing, it is meant to be, partly out of respect for what these guys do.”

“This production had an intensity that was very similar to the nature and subject matter of what we were filming,” concluded Tim Burke. “At times it felt like we were in the middle of a war zone, work-ing in a guerrilla film unit— and I think that reflects in the final film, giving it a very gritty documentary feel. That was certainly the way we approached the visual effects. Rather than shooting stylized effects that stood back as events unfolded before them, we let Ridley and his cameramen position their cameras for soldiers’ points of view, very raw and handheld. It was as real as we could make it.”

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Ring Masters

image

ARTICLE BY JODY DUNCAN

In a hole in the ground there lived a hobbit.

Those words popped, inexplicably, into the head of Oxford University professor J.R.R. Tolkien one day as he graded student papers. Years later, in a letter to poet W.H. Auden, he confessed that he did not know why he had thought that mysterious sentence and then written it on a blank sheet of paper; but from that seemingly insignificant scrawl, he would develop an ancient history and society, draw detailed maps, and even craft languages for an imaginary world he called Middle-earth.

Tolkien's children witnessed that world's genesis during cozy evenings at home, when their father, a natural storyteller, stood in front of a roaring fireplace and spun beguiling tales of little beings he called hobbits. Tolkien's fireside stories were shared with the world in 1937 with the publication of *The Hobbit or There and Back Again*, an account of how hobbit Bilbo Baggins goes adventuring from his home in the pastoral Shire and returns with a mysterious ring of power. *World War II* was consuming Europe when Tolkien began writing *The Lord of the Rings*— set sixty years after Bilbo's adventures— the first volume of which saw publication in 1954.

The Lord of the Rings has since sold 100 million copies worldwide, spawning generations of fans. However, the complexities of Tolkien's literary trilogy had long frustrated filmmakers— reportedly even Walt Disney and Stanley Kubrick— who had considered translating it to the cinema. Animator Ralph Bakshi produced an animated *Lord of the Rings* feature in 1978, but it took the vision and nerve of New Zealand director Peter Jackson to finally realize it as a live-action epic.

The odyssey began as the director's supernatural thriller, *The Frighteners*, a 1996 Universal release, approached the end of its postproduction at Weta Digital, a home-grown visual effects facility founded by Jackson and his Weta Limited partners, Richard Taylor and Jamie Selkirk. Weta Digital had been launched with just one workstation producing thirty CG shots for Jackson's *Heavenly Creatures*, a 1994 drama based upon a notorious mid-1950s matricide case in New Zealand. By the time *The Frighteners* went into production, in late 1995, the facility had blossomed to accommodate some twenty CG artists working on 570 visual effects shots for that film. "Once *Frighteners* was finished," Jackson recalled, "we knew we'd have no more effects for Weta to do, and we were wondering what would come next. I began thinking that I'd love to do a Ray Harryhausen-type fantasy, with fantastic creatures and extraordinary worlds— a '*Lord of the Rings* type of film' is how I envisioned it. It was then that we began looking into the rights for *The Lord of the Rings*."

Jackson pursued those rights, held for years by producer Saul Zaentz, and a back-to-back, two-film production was planned under the aegis of Miramax. During an eighteen-month-long preproduction, Jackson, together with his wife and screenplay collaborator Fran Walsh and screenwriter Philippa Boyens, prepared two hefty shooting scripts while Weta's visual and special effects arms— Weta Digital and Weta Workshop— developed everything from crowd simulation

software and CG creatures to props and prosthetics. Throughout, concept art was being produced by the team.

Key to that effort were Alan Lee and John Howe, re-nowned illustrators of Tolkien's world. "One of the things that was unique about this project," noted Jackson, "was that at the time we began developing the script, there had been forty years' worth of artwork done for *The Lord of the Rings*. So as we wrote, we also gathered together every piece of Tolkien art we could find. Some pieces inspired us, and some did not; but it was helpful to see how other people had visualized the books' places and characters.

"Amongst all the artists who have done Tolkien illustrations over the years, we were most impressed with Alan Lee and John Howe. Alan's watercolors captured the romance, the beauty, the soft light and the gentle-ness of Middle-earth, whereas John's renderings really captured the drama of it, specifically when it came to depicting Middle-earth's forces of evil. It was all very inspirational stuff. After about a year of writing, we thought it was crazy just to sit there and stare at these old illustrations Alan and John had done— why not invite them on board and see if they wanted to work on the movie?" Howe and Lee did join the project, and spent the next many months producing concept art for the film.

But, suddenly, all of the film preparation— set and character design, script polishing, the ramp-up of Weta Digital— was brought to a halt as Miramax balked at the cost and risk involved in committing to two films. As a compromise, the studio proposed narrowing the focus to just one. "We said, 'You mean you want to make Part One first; and then, if that is successful, you'll make Part Two?'" Jackson recalled. "And Miramax said: 'No. We want the entire story of *The Lord of the Rings* in one film.' So then we asked them if it could be a *Lawrence of Arabia*-style, four-hour-long epic film; and they said, 'No, it has to be two hours.'

"This was at the end of eighteen months of hard work, and we were suddenly having to agree to do one two-hour movie and get rid of a whole bunch of characters and a lot of the story. We told them we couldn't shorten *The Lord of the Rings* by that much and still call it by that title. It would be very misleading to anyone who had read the books. So Miramax gave us a four-week period to take it somewhere else. If, at the end of that period, we had not found a studio, they would take back the rights, dis-involve us, and find someone else to make this two-hour film."

Anxious at the prospect of his labor of love slipping from his hands, Jackson responded quickly, orchestrating a twenty-five-minute 'making of' film that documented the creative work that had been done in the previous eighteen months. Alan Lee and John Howe were interviewed for the documentary, which also showcased their concept art. Cinematographers came in to photograph maquettes and miniatures that had been built at Weta Workshop. The documentary also revealed computer graphics tests being done at Weta Digital. "We were desperate," Jackson confessed. "The movie was collapsing around our ears— so we were all being interviewed for our documentary wearing happy, smiling faces whilst feeling utterly sick and appalled."

The clock was down to just two-and-a-half weeks when Jackson and his team flew to Los Angeles with their documentary, the two scripts and a budget breakdown for two productions. They had made the rounds of other studios to no avail by the time they met with New Line Cinema chairman and CEO Robert Shaye. New Line, they knew, was their last hope. “We screened the documentary for Bob Shaye,” Jackson recalled, “and it was the most excruciating experience. The whole time he just sat there, not reacting at all. At the end of it, Bob turned and said, ‘I don’t understand.’ My heart dropped. Oh, God! This is the end! Then he said: ‘I don’t understand why you’d want to make one or two movies when there are actually three books. Why wouldn’t you make three films?’ ‘Well... if you’d like us to make three films, we’d be very honored, indeed, to do that!’”

New Line agreed to back three films— *The Fellowship of the Ring*, *The Two Towers* and *The Return of the King*— each of which would be directed by Jackson and released in three subsequent Christmas seasons, the first scheduled for 2001. The audacious plan was to film all three movies simultaneously in a marathon, fifteenmonth shooting schedule based in New Zealand, where the director had been building up a production infrastructure since his teenage days of shooting *Super-8* films. That infrastructure consisted of a Wellington production hub, complete with soundstages, as well as Weta Digital and the 68,000-square-foot facility that housed Weta Workshop.

Unlike the relatively embryonic Weta Digital, Weta Workshop— overseen by partners Richard Taylor and Tania Rodger— had been a functioning entity for four-teen years, operating under the name RT Effects before being folded into the Weta organization. Taylor— whose expansive credit on the show would eventually read ‘special makeup, creatures, armor, weapons and miniatures designer and supervisor’— had worked closely with Jackson on most of the director’s previous films. During that long collaboration, both men had lived what many of the *Lord of the Rings* newcomers were about to learn: that filmmaking is a far different proposition in the isolation of New Zealand than it is in Los Angeles or London.

“There is a certain level of what is called ‘Kiwi inge-nuity’ within the New Zealand film industry and Weta,” stated Taylor, “an ingenuity that has been born out of necessity. Until six years ago, we hadn’t really come into contact with other effects facilities. We had worked in almost complete isolation and, consequently, had developed all of our own techniques and skills and vocabulary. The first five or six years of our business, for example, we had no access to clay or plasticine, the sculpting materials used in effects workshops around the world. So we sculpted all of our characters out of edible table margarine. It’s a harder margarine than what you get in the States— but it was still margarine. I’ve sculpted animatronic cows in margarine; I’ve sculpted spittingimage satirical



The scope and complexity of J.R.R.Tolkien’s epic trilogy, The Lord of the Rings,had frustrated efforts to translate the books into film for fifty years before New Zealand director Peter Jackson took on the task. In a marathon shooting schedule,Jackson completed live-action photography for three successivefilms,then hunkered down with his Weta Workshop and Weta Digital crews to create some 1500 visual effects shots for the trilogy.In the inaugural release, The Fellowship of the Ring, the wizard Gandalf arrives in theMiddle-earth village of Hobbiton to celebrate the birthday of his good friend Bilbo Baggins.

puppets of New Zealand politicians out of margarine. Because of our isolation, we've had to learn how to make silk purses out of sows' ears."



An expansive prologue depicts a centuries-old battle pitting an alliance of elves and men against hordes of warrior orcs serving the evil Sauron, ruler of Mordor. For wide shots of the fierce fighting, Weta Digital— under visual effects supervisor Jim Rygiel— composited live performers in costume and makeup into the foreground, filling out the frame with vast computer-generated armies. Digital color grading, a postproduction process Jackson employed throughout the film to imbue New Zealand locations and wholly fabricated environments with fantastical qualities, established a dark and moody look for the sequence.



Live-action combatants in the prologue were filmed against bluescreen. As many as seven shooting units – a first unit, three second units, two miniature units and a bluescreen unit – operated simultaneously throughout the taxing fifteen months of principal photography, all linked to Peter Jackson via satellite.

That isolation has also engendered a rugged, can-do attitude among native New Zealanders. "You learn very early to make your own fun," Taylor elaborated, "and, in the process, you pick up the mindset that if you just give it a go, you can make anything work. Peter Jackson totally encapsulates that idea. At the age of eight, he started making his own little films; and right through his teen years he filmed every weekend, building his own camera equipment, his own Steadicams, his own dollies.

That kind of inventiveness, and just the willingness to give it a go, made all of us believe that we could take on *The Lord of the Rings*.”

Besides Kiwi ingenuity, another local phrase that applied to the production was ‘putting it together with #8 fencing wire,’ a term stemming from New Zealand’s predominantly rural culture. “It comes from the farm,” said Taylor, “and it means that if you want to fix something, you twist it together with a piece of old fencing wire. I grew up on a farm, as did a large percentage of the people we hire here. A rural upbringing requires a lot of repairing, fixing, creating and building; and that background has given us the basic training, motor skills and handicraft to do this kind of work. It has also resulted in an uncluttered, non-slick approach. I like to think it has given us a unique flavor, as well.”

Basing *The Lord of the Rings* in his homeland not only gained Jackson access to native ingenuity, it also allowed him to re-team with local veterans of his past shows, such as production designer Grant Major, physical effects supervisor Stephen Ingram and costume designer Ngila Dickson. New to the Jackson fold were producer Barrie M. Osborne, associate producer Ellen M. Somers, director of photography Andrew Lesnie, and Mark Stetson, who served as visual effects supervisor during principal photography, with Jim Rygiel taking over the role for postproduction and beyond.

The arduous principal photography schedule, which commenced in October 1999 and wrapped in December 2000, required a cast and crew of 2500, and as many as seven units shooting simultaneously: a first unit, two or three second units, two miniature units and a blue-screen unit, all linked to Jackson via satellite. “Most of the time,” Jackson noted, “the key units would be fed by satellite onto whatever set I was on. Sometimes second unit was shooting right on the stage next door to me, and I would be able to just wander in and communicate that way. Other times I would be shooting on a stage, and they would be on location down on the South Island, a couple of hundred miles away. In those instances, I’d be looking at a bunch of TV screens.”

In addition to its fractured, multi-unit nature, the 274-day shoot was three to four times longer than a standard principal photography schedule, requiring an unprecedented level of commitment from Jackson and his crews, as well as tremendous physical and mental endurance. “In some respects,” noted Jackson, “the biggest hurdle we faced in this production was the physical strength it required. I worried about whether or not everybody would have the stamina to go through a film production three times, back to back. When I came off *The Frighteners*, which was an almost six-month-long shoot, I was barely able to function. You time your body to get through the shoot period; and then, when the end is in sight, you feel things starting to give way, and you end up sick in bed the day after the film wraps. So it is a mind and body thing.

“In this case, everyone had to tune themselves into shooting for nearly fifteen months— and that didn’t count all the preproduction and postproduction stuff. Ultimately, it was a psychological hurdle.” In part, Jackson and his crews cleared that hurdle by thinking of the three separate films as one long movie that would consume eight hours of screen time. “People referred to ‘Film One,’ ‘Film Two’ and ‘Film Three,’ but there was a mindset amongst everybody that we were really telling one story, and that minimized the complexity.”

To some extent, the visual effects, like the live-action photography, would also be tackled simultaneously, with each of the 1500 effects shots for all three films in some stage of the Weta

Digital pipeline— if only design and previz— by the time the first movie was released. Weta Digital would handle all but a few of those effects shots, requiring a ramping up in staff to more than 200 CG artists from around the globe. “We had people from England and the United States,” noted Weta animation supervisor Adam Valdez, “from Russia, India, France, Japan— all drawn to this island in the middle of the ocean because this felt like a special show.”

Logically, the most concerted effort in the first phase of production was aimed at the 500 effects featured in *The Fellowship of the Ring*. The inaugural film introduces hobbit Bilbo Baggins (Ian Holm), who decides to leave his home in Hobbiton and bequeath all his possessions— including the ring he found in the course of his wanderings six decades earlier— to his cousin, Frodo Baggins (Elijah Wood). The occasion is Bilbo’s ‘eleventyfirst’ birthday, marked by the arrival of old friend and wizard Gandalf (Ian McKellen).

Noting the ring’s disturbing hold on Bilbo, Gandalf leaves Hobbiton to seek answers, and returns with the terrible knowledge that the ring is the One Ring sought by the spirit of Sauron, ruler of the dark land of Mordor. The once-sleeping spirit has now awakened, garnering all the evil forces of Middle-earth to claim the ring, whose mystical power is foretold in a hidden inscription: One Ring to rule them all, One Ring to find them, One Ring to bring them all and in the darkness bind them.

The only hope for the good hobbits, men, elves and dwarves of Middle-earth, Frodo later learns, is to destroy the ring by journeying to Mordor and casting it into the volcanic fires of Mount Doom, where it

was originally forged. Reluctantly, Frodo takes on the responsibility, ultimately joined in his quest by Gandalf, fellow hobbits Samwise Gamgee (Sean Astin), Pippin Took (Billy Boyd) and Merry Brandybuck (Dominic Monaghan), the elf Legolas (Orlando Bloom), the dwarf Gimli (John Rhys Davies) and the men Aragorn (Viggo Mortensen) and Boromir (Sean Bean)— a nine-member fellowship that bravely begins the journey to Mordor, fighting Sauron’s evil forces at every turn.

Structured essentially as a ‘road’ picture, *The Fellowship of the Ring* had to establish an entire geography and look for Middle-earth, put forth by Alan Lee and John Howe in voluminous sketches and paintings. “We had design meetings every day during preproduction,” recalled Lee. “Peter would talk about his ideas for a particular environment, and we’d go off and begin drawing. Grant and Richard and their people were involved, as well. Our brief was very broad at first; then gradually we’d hone in on what was going to work dramatically for Peter, and what would provide the greatest spectacle and the right atmosphere. I was told by someone, well after the fact, that I had done a thousand drawings on large sheets of paper; and I would imagine there were at least another thousand or so on smaller pieces and in sketch books. Sometimes I’d do ten a day. It was the most sustained and exhausting period of work I’ve ever had— and the most exhilarating.” In addition to



The defeated Sauron erupts in an explosion of light amidst the amassed opposing armies. Some shots within the prologue battle had up to 100,000 combatants, all created digitally through an in-house crowd simulation program called ‘Massive.’ In development for more than five years, Massive used digital agents programmed with simulated senses of sight, hearing and touch to produce ‘thinking’ characters capable of autonomous behavior.

the drawings and watercolor renderings done by Lee and Howe, more than 300 acrylic paintings were created in the production art department.

Jackson's intention, stated from the outset, was to conjure a Middle-earth that reflected Tolkien's vision but was also firmly grounded in reality. To that end, the director encouraged his designers to think of *The Lord of the Rings* as a historical account, rather than a fantasy. "Ancient history is fantastical to a certain extent," Jackson stated. "If we were transported back to ancient Rome, we'd think of it as slightly fantastical because it is so different. That's how we approached this. At the beginning of the project, I had everyone imagine that *The Lord of the Rings* actually took place, as Tolkien had suggested, on our earth some seven or eight thousand years ago, and that all these locations and cultures actually existed at one time. All that we as a film crew were doing was dressing actors in authentic costumes and taking our cameras out to where these historical events took place to re-create those events. It was critical to me that nothing look artificial or fake."

It was his familiarity with the region and his already established production base in New Zealand, more than anything else, that prompted the director to shoot the trilogy there; but a more perfect location for Middle-earth could not have been found. New Zealand offered enormous geographical diversity, from rural farmlands to exotic mountainous regions. Wide open spaces were also ample—New Zealand's North and South Islands together form roughly the land mass of the British Isles, but are populated by only three million people. "The South Island is very rugged and mountainous," Barrie Osborne observed, "and at the tip, which points toward Antarctica, it gets very cold and snowy, and there are alpine-like mountains and fiords. Then, the further north you go, the more tropical it gets, with places such as volcanic Mount Ruapehu in the North Island."

Despite its rich and diversified geography, however, New Zealand could not represent all of the story's fantastic locations, many of which were created



Gandalf (Ian McKellen) shares tea with Bilbo (Ian Holm) at the hobbit's Bag End home. Because Jackson opted to cast regular-sized actors as the three-and-a-half-foot-tall hobbits, a variety of techniques had to be employed to sell the illusion of hobbit scale. Among them was in-camera forced perspective, wherein hobbit actors and scaled set pieces were placed farther away from camera than they appeared, making them smaller in frame.



Another scaling method was to shoot the larger character in an undersized set and the smaller character in an oversized set, often with the other-scaled character bluescreened in or replaced with a scale double. McKellen and Jackson confer on the undersized Bag End set.

through miniatures, either standing alone or in combination with live-action plates. Even midground views and fill-in areas, traditionally the realm of matte painting, were most often achieved with miniatures. “I’m not a big fan of matte paintings,” Jackson allowed, “particularly when they’re used for architecture and cityscapes. If you want rolling hills off into the distance, or jagged cliffs, or any other kind of natural landscape, matte paintings are believable. But I’ve always been more miniatures based, given the choice of one or the other.”

Miniatures were also the approach of choice over 3D computer generated sets, few of which would appear in the final film. “We could have made 3D sets, of course,” said visual effects director of photography Alex Funke, who oversaw the filming of all the miniatures, “but the amount of effort it would have taken to make them look real was tremendous. It was actually easier and better to do it with miniatures. We could build one gorgeous miniature that was beautifully detailed— so detailed we could literally shoot it from an inch away— and we had the realism all there, built in. We had light refracting from the tiles of the roofs the way it really would, we had shadows. We didn’t have to invent anything. That was Peter’s thinking— a miniature is real. But it was a daring use of miniatures, and a pretty bold thing to do for a picture of this magnitude. We were talking about hundreds and hundreds of miniature shots for the three films; and that was a huge commitment of personnel, time and equipment.”

Weta Workshop built 68 miniatures for the three shows. Though a variety of scales was used, fourteenth scale was typical— a large-enough size to allow for fine detailing, yet small enough to fit inside the Workshop buildings. Even at that scale, the miniatures were enormous. “We coined the phrase ‘bigatures,’” remarked Richard Taylor, “because a high percentage of these miniatures were bigger than houses. A number of them were bigger than the full-size sets normally built for a film! The reason for that was Peter’s desire to generate the immense scale and size of environments that Tolkien described in his books. These environments allowed a great deal of flexibility in motion control camera moves and big fly-throughs and so on, to create the massive scale of this world. Alan Lee would draw these huge environments, then sketch human figures within that drawing at a very small size. If we were to build a miniature that would hold up in detail, we likewise had to build them very large.”

The miniatures crew was typical of the Workshop staff in that it was comprised largely of film industry novices. As a result, training of technicians and craftsmen for *The Lord of the Rings* was a major undertaking in its own right. “In the miniatures department,” noted Taylor, “we had only two people who had ever built miniatures within the film industry. We had people who were highly skilled in other areas, and we had young people just willing to give it a go, but we had to go through



Dawn breaks over Minas Tirith, the ancient Gondorian city where Gandalf seeks answers to the dark mystery of the powerful ring that has been in Bilbo’s possession for decades. Weta Workshop built the city miniature, which was then shot by one of several miniature photography units that remained in continuous operation from the start of principal photography through the initial film’s release, and well beyond. Weta Digital composited the miniature with a digitally-enhanced location plate. Bluescreen figures tracked to the battlements added movement and life to the shot.

a fairly extensive period of training to get everyone up to speed. We also had to come up with ways to produce a huge number of miniatures inexpensively and with this relatively inexperienced crew.”

One shortcut in building miniatures, many of which would stand in for Middle-earth’s cliffs and mountainsides, was to create a library of generic rock face molds. “We went to the coastline around Wellington, which is only a two minutes’ drive from our workshop,” Taylor continued, “and took massive silicone molds off the rock faces there. Then we brought those back to the shop and sprayed up libraries of insulation foam urethane sheeting, so we could create stockpiles of rock face. Through that process, we were able to very quickly build huge rock structures fitted to large steel frames.”

Miniature photography commenced in October 1999, concurrent with the start of principal photography, and continued through the release of the first film and well beyond. “We concentrated on the first film,” observed Funke, “but we were also shooting elements for the second and third films because that was the most efficient way to schedule the work. If we were going to shoot a miniature that was in twenty shots in the first film and two or three shots in the second film, of course we shot all of those elements, since the setup was already in place. So, even as we got to the end of production on Film One, we already had material for Film Two. In fact, we kept shooting miniatures for Film One right up to the last minute, as Peter continued to re-edit, restructure and refine the movie.”

A benefit to the preponderance of miniatures in the film was that it gave Jackson free rein in executing extremely dynamic camera moves, resulting in an epic, sweeping cinematic style. “Shooting miniatures made for an audacious use of the camera,” stated Jackson, “and enabled me to move the camera in a spectacular way. On a location or a set, you’re locked to the laws of physics: how quickly can you push a dolly along, how quickly can you move a crane through the air, and what can a helicopter do? But on the miniatures, I could be more dramatic with the camera moves, traversing a seemingly huge area, which would have been impossible to do in reality. In real scale, you could never find a piece of equipment, or even a helicopter, that could do that move. With a fifth-scale miniature and a motion control camera, I could sweep through the air in ways that, otherwise, would be impossible.”

One school of thought maintains that doing such dramatic moves on a miniature destroys its illusion of reality— but Jackson did not hold to that theory. “People would come up to me, and say, ‘Well, you know, you’re doing an impossible camera move there,’” Jackson. recollected. “But I never wanted to be locked down by that sort of thinking. I enjoyed doing these big, arcing, sweeping moves, as long as they were appropriate for the scene. I also felt it assisted the grand, epic nature of



Bilbo relinquishes the ring— determined by Gandalf to be the ruling ring of power that must be kept from Sauron to prevent his gaining dominion over Middle-earth— to his cousin, Frodo Baggins (Elijah Wood). Fleeing Hobbiton, and under attack from Sauron’s murderous disciples, Frodo slips on the ring and becomes invisible, entering an alternate reality the production dubbed ‘wraithworld.’ The chilling wraithworld effect, which would recur throughout the film, was characterized by high-frequency streaking and whirling vortex images. To create the effect, Weta Digital artists emitted 3D particle streams off of tracked 2D plates, then smeared them using software developed in-house.

the film. Ultimately, I think it took people's minds off the fact that it was a miniature, because we are so accustomed to seeing miniatures used in fairly conservative ways. I thought that if I kept the camera moving dramatically, people would be sucked into the drama of what was happening, rather than focused on the tricks we were using."

While miniatures would remain predominant, more matte paintings began to make their way into the film as Jackson's position regarding them shifted. "Towards the end of the project," related Jackson, "we came up with some very good paintings. I learned that as long as matte paintings are based on photographic elements, they can look extremely realistic. If you can take pictures of forests or mountains and assemble them together into a collage and paint in between, add little 3D elements and a camera move, they look fine. On location, if we ever saw clouds or a sky or a sunset that looked dramatic, we always put cameras on it and shot it; so that over a period of time, we compiled a library of dramatic skies that we could patchwork in with painted elements."

To capture more photographic elements for matte-painted backgrounds, Mark Stetson organized a dedicated scenic unit consisting of visual effects art director Paul Lasaine, acclaimed landscape still photographer Craig Potton and cinematographer Alun Bollinger, who shot movie footage. The unit roamed New Zealand for two months by helicopter and four-wheel drive, shooting hundreds of locations, from glaciers and volcanoes to coastlines and mountaintops.

While film footage obtained by the scenic unit relieved the first and second units from having to shoot establishing and background plates during the tightly scheduled location stints, the still photography would prove equally important. "The basis for a lot of the matte paintings were tiles projected onto the inside of a spherical environment and stitched together as an un-wrapped 3D image," said Gray Horsfield, who oversaw the Weta Digital environments department. "Typically, we would do a stitch of the tile picks, using a Weta tool to create a network of projection cameras that matched the



In his wraithworld state, Frodo sees the spectral forms of his assailants, called the Nazgûl—once-mortal kings, seduced and corrupted by the rings of power, who now serve the waking spirit of Sauron. Weta Workshop, under the direction of longtime Jackson collaborator

positions and orientations of the stills camera in 3D space. The tile images were projected through their matching 3D cameras to create a 360-degree environmental projection. Then we modeled the environment as geometry to line up with the projection. We could take any sample from that projection and have matte painters create something more fantastical than the New Zealand locations, and layer that paint work back onto our environment projection.”

Richard Taylor, designed and fabricated prosthetic makeups for the Nazgûl and other characters in the film.

Even the most traditional matte paintings were distinguished by a higher-than-normal resolution, a means of dealing with the director’s constantly moving camera. “Peter moved the camera a lot,” related Jim Rygiel. “I don’t think we had one real lockoff in the entire show. So what we ended up doing was overpainting the matte paintings, making them 3K to 6K wide— triple the normal resolution— which gave us the freedom to move around wherever we wanted to in the shot.”



Under normal conditions, the fierce Nazgûl– or ‘ringwraiths’– are faceless phantoms, cloaked entirely in black and galloping hellbent on enormous blacksteeds. Their cadaverous features become visible only in wraithworld. Photography of live performers in the multiple-appliance Nazgûl makeups was image-processed in postproduction to create the glowing spectral look.



Ringwraiths in pursuit of Frodo and the ring are swept away by water horses, summoned by the elven magic of Arwen (Liv Tyler). The sequence was awarded to Digital Domain, which created the water horses through volumetric animation tied into the company’s in-house fluid simulation program. Digital Domain effects artists rotoscoped and reassembled live-action elements of the dark riders charging toward camera, to establish

composition, then key-frame animated subsequent shots of fallen riders tumbling in the cascading water.

The Fellowship of the Ring would not only establish, through matte paintings, miniatures, stage sets and locations, the geographical world of Middle-earth, it would also lay the aesthetic foundation for that world's human, elf, dwarf and hobbit cultures, each of which required distinctive sets, props and costumes. "We set out to create the iconographic look of each of these cultures," noted Richard Taylor, "so when you looked at the film, you immediately would be able to tell the difference between them. A dwarf, for example, is short and stout; so the geometry of dwarf armor was square and boxy and geometric. The motifs of the elven armor, in contrast, were very nature-driven and spiritual looking.

"There were 28 leads in this film, and they all needed their own graphic design—the motifs that are stamped into their belts, the belt buckles, the way they lace their boots, the way they tie their cuffs together. All of that had to be unique to that particular character and culture. We also had to serve the preconceived idea of what these creatures would look like. People have been reading about these characters for fifty years, so we had to encapsulate the world's vision of these creatures and Peter's vision, trying to put an original touch on them."

Weta Workshop designers produced from ten to two hundred drawings for any one character. As Jackson narrowed down the designs, the Workshop began sculpting sixth-scale maquettes—made out of Super-Sculpey, rather than margarine. "We created a couple hundred design maquettes for the film by the time we were done," said Taylor. "From these original design maquettes, we would then sculpt larger, more detailed maquettes that the digital effects department would scan as a means of creating the digital creature models. We also used Photoshop extensively, compositing photographs of the maquettes into environments to better illustrate the way the characters would look in the film."

While the production art department and Workshop designers conceptualized environments, props and characters, a storyboard team developed the sequences shot by shot, turning out as many as



An establishing shot of Rivendell, the enchanted elven retreat that serves as sanctuary for Frodo—wounded by the ringwraiths—and his hobbit companions. A partial live-action Rivendell set was built at a regional park near Wellington—the production's New Zealand home base—but expansive views required a variety of miniature and matte painting enhancements. For wide and medium shots of Rivendell, Weta Workshop built a camera-ready model featuring scaled trees and cast-urethane rock faces.



Frodo looks out on Rivendell from a balcony in the House of Elrond. A balcony set piece was shot bluescreen, then combined with miniature photography and live elements captured by a dedicated scenic unit. Still and moving images photographed during that unit's four-month trek across New Zealand were incorporated into both live and miniature environments. Scenic elements, tiled and enhanced with matte-painted touches, also formed the basis for far-distant CG cycloramas.

100 thumbnail sketches a day for a first-pass look by Jackson, with pages inked and shaded for subsequent review.

Visual effects art director Christian Rivers headed up the storyboarding, as he had for all of Jackson's projects in the preceding ten years. "The storyboarding on this project was different than what we've done before," said Rivers. "We'd done some storyboarding early on — when the film was still with Miramax— but by the time we came back to it, after Peter had finished the script, a huge amount of stuff had already been designed. So we had models of most of the sets— just little cardboard models for the Prancing Pony or Bag End, for example, built by the art department. We also had little scale figures to match the actors. We'd use those models and figures to block out shots."

Jackson choreographed sequences on the miniature sets, shooting them with a lipstick camera, then viewed that footage on video. "We had a video unit set up with a still frame-grabber and a monitor," Rivers explained. "As we watched it, Peter would tell me to freeze a frame; then I'd grab that from the monitor and sketch storyboards straight from the frame. In instances where we didn't have the miniature sets or figures, the storyboard process was more typical— I'd sit in a room with Peter and thumbnail-out shots as he described them to me."

Storyboards alone were not sufficient, however, given the complexity of the project. Nearly every shot— both live-action and visual effects— was first created as a 3D previsualization. Veteran effects artist Randall William Cook directed the previz effort, initiated in October 1998, before segueing into his role as animation designer and supervisor. "I was very excited about *The Lord of the Rings*," Cook recalled about his early involvement. "Five percent of my excitement was about the project itself, because as a teenager, I had always thought *The Lord of the Rings* would be the ultimate fantasy picture. But ninety-five percent of my excitement was about working with Peter Jackson, because I knew he was the guy to turn this into something special. I had met him several years before, and it was evident to me that he not only knew all about moviemaking and effects, he also knew literature and art and a lot of other things. I couldn't imagine anyone who would be a better choice for directing this picture. So, basically, I packed up, left friends and family, and moved to the other side of the world for Peter Jackson. When I arrived in New Zealand, a lot of work had been done with graphite and wood-pulp storyboards— but Peter also wanted pixels."

'Pixels' meant 3D animatics. Prior to the start of production, Cook, Jackson and a few Weta principals visited Industrial Light & Magic to get a closeup look at the current previz technology and technique. "I had never before seen previz on a grand scale," Cook admitted. "It didn't change any of my ideas— I've been designing scenes for movies for twenty years— but it was a revelation that you could basically make an elaborate puppet movie in the computer."

The previz team included associate producer Rick Porras, coordinator Marion Davies and animators David Scott, Imrey Watson, Kyle Ashley and Jake Lee. Visual effects cinematographer Brian Van't Hul, hired in 1998 to head the Weta Digital camera department, oversaw the initial previz setup in 3D Studio Max. "The entire film, beginning to end, was cut together with music and dialogue, using a combination of storyboards and 3D previz," noted Van't Hul. "Then, as we started shooting the live-action, Pete would substitute the previz and the storyboards for the live-action material coming in. That way, he could continually look at the picture as a whole, and get a better feel for how the

setup of story points was evolving. Peter had a full-length version of the film in some form for quite some time, and I think it really benefited him in continually making the story better and the sequences more exciting.”

Although most of the movie’s big action scenes were developed in previz, the prologue battle that opens *The Fellowship of the Ring*— set in Mordor in an earlier age, when an alliance of elves and the men of Gondor defeat Sauron and his army of orcs— did not go through the established previz loop, largely because Jackson made the final decision to add the sequence, and shot most of the stage elements for it, very late in production. As a result, he relied on storyboards and images captured by his lipstick camera on a giant clay table-top model to plan the sequence.

“Peter and Christian Rivers got together one weekend,” stated digital model supervisor Matt Aitken, “and created that environment very organically, just throwing up gobs of clay and sculpting. They built up the landscape that they wanted to play the battle out on— ‘We can put a bluff here, and a river through there, and a whole horde of orcs can run down this slope here, and this is where they can clash with the elves.’ They developed the whole thing and blocked out all the action; and by the time the weekend was over, they had a nicely detailed, eight-by-four-foot physical sculpt of the landscape for the battle.” That model was scanned, resulting in a dense, heavily detailed polygonal landscape model. “We added some detail, painted texture maps and wound up with a digital version of the clay tabletop model Peter and Christian designed.”

That digital landscape was extended through matte paintings to show all of Mordor and its range of volcanic mountains, including Mount Doom. “The background was actually a split between the 3D geometry and matte paintings that we did on multiplane cys,” observed 3D supervisor Wayne Stables. “At the point in the landscape where we figured we wouldn’t be seeing any parallax or perspective changes, we put in our cys.”

Live-action elements for the prologue battle were captured on stage or at Mount Ruapehu, a rugged volcanic area with a boulder-strewn terrain. As it happened, the area’s mounds of volcanic rock resembled miniature volcanoes in the eye of the camera; and so, much of that plate material was used as a scaled environment. “This location had real volcanoes in a desert of ash,” stated 2D supervisor John Nugent, charged with compositing the prologue sequence, “so the environment was quite authentic and worked very well as it was. The geographic elements weren’t exactly what they needed to be, however, so we had to enhance them with mattepainted mountains in the distance and interesting cloud formations.”

Stunt coordinator George Ruge staged live-action elements for the prologue battle, while veteran action coordinator Bob Anderson choreographed individual swordplay. “For Middle-earth,” remarked Anderson, “the swordplay had to be vicious and heavy and violent. It is a land that has the feel of medieval times, and medieval swordplay was hack and bash.”

Swords and armor employed in the battle scenes were among the props fashioned by Weta Workshop. In addition to 100 hero swords, made for tight closeups, the Workshop turned out lightweight aluminum blades for actual fighting, and thousands of background swords, spears and crossbows. “One of the things I was very insistent upon doing,” commented Richard Taylor, “was to not let the armor and the weapons and the props of Middle-earth look as if they had come from a 1990s art department. It was imperative that they not look as if they’d been over-designed or made

by technology that wasn't in use in the fifteenth century of our world, and therefore wouldn't be relevant to Middle-earth. So, to that end, we set up an authentic blacksmith shop and brought in artisans skilled in many ancient crafts to create these things.

"The idea was to invest the props with a high level of richness and heraldry and realism. All the detailed hand guards were cast in bronze and semi-precious metals, and the hilts were hand-carved out of exotic timbers from around the world. The hero blades were blunted so we didn't run the risk of cutting anyone, but they were real weapons that could have been sharpened and used in battle." Distant background bows, spears, swords, shields and crossbows were built through a process in which urethane rubbers impregnated with lead shot were cast out of silicone molds.

When it was all over, the Workshop's output for the entire trilogy totaled more than 48,000 separate items, including 1000 suits of hand-crafted armor, 500 suits of hand-sewn leather, and more than 2000 weapons— each crafted with detail that went far beyond what the camera would ever pick up, just to achieve an overall sense of authenticity.

All of the effort in prop design and fabrication was on top of the Workshop's character design work, the sculpting of maquettes, and the building of miniatures and prosthetics. "I chose to take on an insane amount of work because it was necessary to create a truly integrated, Tolkienesque brush stroke over the three films," Taylor elaborated. "I was convinced that if things like armor and weaponry were farmed out to other companies, we'd lose the integrity of the design aesthetic. The issue was making it feel as if the orcs, for example, had built their armor and weapons. The honest way to do that was to design it all under one roof. We were fortunate that we could always go back to the bible, the written word of Tolkien, who went to incredible lengths to describe this world."



The filigreed Rivendell model was constructed in a modular fashion, on rolling casters, so that it could be detached and reassembled quickly and easily to accommodate any conceivable composition. In some instances, the miniature set was broken down and arranged in layers— background, midground and foreground— each photographed separately so that perspective shifts could be introduced, after the fact, during compositing.

Included in Weta Workshop's contribution to the prologue battle were the design and production of prosthetic makeups for the orc performers. Hero orc characters close to camera wore full facial appliances, body prosthetics, and hands and feet, all made out of foam latex. Background characters were fitted with foam latex slipon masks and body suits. On-set makeup application was overseen by prosthetic supervisors Gino Acevedo, Marjory Hamlin and Dominie Till, as the volume of work was more than one supervisor could handle. "The hero orc makeups took between four to five hours to apply in the mornings," Acevedo noted, "then we had to blend in the pullover foam masks for the midground characters around the eyes. Finally, we had to deal with the pullover masks for all the background characters." The prologue battle required a core makeup crew of eight and a total support crew of fifty technicians to apply as many as ten hero orc makeups, up to fifty midground characters, and as many as 200 background ones.

Over the length of the production, the Workshop fashioned more than 10,000 foam latex facial appliances to serve all three films, as well as silicone and gel prosthetics for seven of the nine lead characters. “We did a fairly comprehensive number of facial appliances in silicone for John Rhys-Davies, who played Gimli,” Taylor commented. “We also did daily gelatin nose applications for Ian McKellen and Christopher Lee, who played the evil wizard Saruman. Ian Holm, as Bilbo Baggins, had gelatin ear appliances put on every day, as well, as did Orlando Bloom and other elf characters.” Hobbit performers sported oversize, furry feet provided by the Workshop. Since a day’s shooting—during which the actors walked, climbed and ran on often rugged locations— would effectively destroy the foot appliances, hundreds of replacements needed to be fabricated throughout production.



A fellowship representing all the cultures of Middle-earth—hobbit, human, elf, dwarf and wizard— leaves the tranquility of Rivendell for the dark land of Mordor to throw the ring of power into the fires of Mount Doom, where it was forged, the only way in which the ring can be destroyed. For his role as Gimli, the dwarf component of the fellowship, actor John Rhys-Davies was fitted with full facial prosthetics.

The prologue battle armies were comprised of not only live-action warriors wearing prosthetics, but also hordes of computer generated soldiers, created through ‘Massive’— Multiple Agent Simulation System in Virtual Environment— the culmination of five years’ work by software developer and crowd supervisor Stephen Regelous. Massive proved invaluable to *The Fellowship of the Ring*, particularly in the epic-scaled prologue battle. “Very early in the project,” said Weta chief technical officer Jon Labrie, “Peter was saying how he’d like to have 50,000, 100,000 people in this battle scene. Steve Regelous had been interested in artificial life for some time; and he thought the best way to give Peter what he wanted was to build intelligent models, or agents, that have smarts— you actually build brains for them.”

An agent’s ‘brain’ was actually a network of rules constructed by a technical director. “The brains didn’t have a physical location in the body,” noted Regelous, “but they looked like the schematic of an actual brain — a network of 7000 to 8000 logic nodes that enabled us to create appropriate responses to environmental stimuli. There were little sliders in the brain that we could use to switch on everything from simple walking to the order to look for an enemy on the battlefield.”

Simulated senses of sight and hearing determined the behavior of any given agent. “An agent could see, essentially,” explained Regelous. “On every frame, he’d get a scanline rendered image of the scene around him. It was a very simple image— distant people showed up as just squares or dots— but it was an image; and the agent was set up to respond to particular images in particular ways. Having an image was important, because it meant that we got around all the limitations of searching a huge database for every frame, which would have brought the system to its knees. The agent would have been reacting to a guy a mile away just as much as he would a guy right in front of him. With vision simulation, the whole database was easy to traverse because we just made a picture of it. We didn’t have to worry if something was relevant to the agent— if he could see it, it was relevant. It was that simple.”

The sense of hearing was an even more simple simulation. Agents had the ability to transmit frequencies to other agents in audible range. “It was sort of symbolic in that they were output values that represented sound, without the actual sound waves,” said Regelous. “It was a physical simulation of the way real sound propagates throughout an environment. All of the different agents would ‘send out’ different frequencies— one sound for an orc, another for an elf— so that the agents ‘receiving’ these frequencies would know if the agents around them were good guys or bad guys. All the good guys were in one frequency range, and all of the bad guys were in another.



Prior to application, hair was hand-punched into the Gimli appliance piece. Costuming, coupled with massive wig and beard, altered the apparent head-to-body-size ratio of Rhys-Davies so as to make him look more stocky and dwarf-like.

“Agents modulated the sounds they were making according to what they were doing, and some of them could respond to that. We ended up using the sound most for walking, because it was more efficient than using vision cues. When they were fighting, they needed to clearly see the other guy, because they needed to make decisions on how to respond based on how the other agent’s body was in relation to them, if a weapon was coming at them, what angle the weapon was coming at them, et cetera. But those kinds of decisions didn’t need to be made when they were just walking around. They all basically hummed as they walked, so they could hear the other guys around them and know not to bump into them.”

Finally, a crude sense of touch was simulated through collision detection—which enabled an agent to respond to collisions with other agents—and information gathered from the terrain of the digital environment. That information told the agent whether or not he needed to adjust his posture to climb up a hill, or sidestep a rock, or jump off or over an obstacle.

The ultimate benefit of the simulated senses of the brain system was that they made for autonomous, rather than assigned, agent behavior. “By simulating the way individuals react to their environment and each other,” explained Regelous, “we got realistic crowd behavior for free. That was more interesting to me than the traditional particle-animation approach of applying forces and fixed animation cycles to little points moving through space. Massive is moving towards creating virtual or artificial ecologies that can evolve and develop on their own.”

Geometries for prototype models, called ‘master agents,’ were crafted by the modeling department, with textures derived from scans of costumed performers. Those master agents were then used to generate tens of thousands of individual agents through instancing. A dozen master agents were created for the prologue battle, with designations based on what each agent was carrying, such as ‘orc sword,’ or ‘elf spear.’ “When the bodies of agents were put together,” observed Regelous, “we specified the variables and their allowable ranges—everything from physical attributes such as height and arm thickness to aggression and resistance to injury. When we populated a terrain with the instances of the agents, the values for those variables were randomly assigned. These copies had their own unique properties. We had more than 20,000 instances in the prologue battle; and, depending on the complexity of the agent, we were able to get up to 50,000 agents into one gigabyte of RAM. For all three movies, we’re planning on building one hundred agents we can instance into thousands.”



Prosthetics supervisors Gino Acevedo and Dominie Till apply the Gimli makeup during principal photography. Because Gimli was supposed to stand just over four feet tall, a corresponding makeup was devised and applied to Rhys-Davies’ diminutive scale double. In the course of production, Weta Workshop produced more than 10,000 foam latex appliances to service all three films. In addition, seven of the nine lead characters required prosthetic makeup fashioned out of more realistic silicone or gelatin.

Motion capture data was imported in Massive to produce a library of motion cycles for the agents to use. For the prologue battle, specifically, the motion capture team captured the combatants running, attacking, stabbing, falling, dying— every conceivable action that might occur in a battle. Once that data was imported into Massive, the agents would determine, frame by frame, which actions to perform.

Typically, more than 200 actions were motion captured per master agent; and with thirty different master agents, that translated to literally thousands of actions imported into Massive. In addition to larger actions, such as running, swinging an ax and falling, each agent had about 350 smaller, individual motions from which to choose. “These smaller actions enabled the agent to react appropriately in many different contexts,” Regelous explained. “For example, he may have a certain sword strike action, but we would capture that six different ways so he would have six slightly different sword strikes available to choose from, depending on whether he was stepping forward at the time he was swinging, or standing still, or raising his shield. So there was this huge motion library, and each of the agents was choosing actions from that entire motion library all of the time. In fact, 24 times per second they were choosing an appropriate action.”

Separate actions were linked into a semblance of fluid motion through a motion blending engine. That engine blended the action of swinging a sword up, for example, with the following striking action. In addition to blending actions sequentially, the engine layered actions atop one another. If an agent needed to walk uphill, the engine would blend the basic walking motion with an uphill motion, where the character leaned forward and moved his legs a bit differently. Similarly, the walking motion could be blended with a sideways move as a means of having an agent walk around an obstacle in its path.

Once the agents had been placed in a scene and the Massive simulation run, the Weta Digital team finessed the actions provided by the computer. “We would see if the agents went in the right direction,” said Jon Labrie, “if they were fighting when they needed to be, dying when they needed to be. We’d check to see if the whole thing was visually compelling. Then we’d twist and push and shape the action a bit using tool sets. We couldn’t always get something compelling by just putting a bunch of figures in there and saying, ‘Fight.’ Choreography tools that allowed us to create more subtle placement and action were very important.”

In some cases, a technical director would choose to override the autonomous behaviors of the agents, if mandated by a particular shot. “You might have one group of guys walking along,” explained Regelous, “and they might decide to pick a fight with another group of guys coming the other way. If we didn’t want that, we could set up the brain in a way that didn’t allow it to happen. We had a fight switch in the brain, and that was one of the variables we could control when we were placing these thousands of guys. We could also switch on the ‘fight’ halfway through a scene, if we wanted them to get to a certain point before they started fighting.”

The TD’s level of control extended to being able to designate the precise point on the terrain at which the agents would engage in combat. “Say we wanted the agents running through a certain gully, then going over the brow of the hill, looking for an enemy and engaging him,” Regelous said. “We could achieve that by putting a flow field into the gully, which is just encoded direction information. The agents respond to those flow fields, as part of the information they receive from

the terrain. We could also paint a spot on the ground to indicate to them that this is where they were going to start fighting. Just by painting and putting flow fields onto the terrain, we could give the agents some indication as to the appropriate behavior. We could control all of that.”

Still, the element of surprise inherent in each new run of the simulation was one of the joys of Massive. “We literally didn’t know what these guys were going to do,” Peter Jackson observed. “I still get a chuckle when I think about one of the first tests, where we had about 2000 foreground guys desperately trying to kill each other; but in the background, about fifty of them had thought the better of it and had turned around to flee the battle! I thought, ‘Those are the smart guys.’ It was extraordinarily spooky.”

After animation was approved, agents were rendered as elements, with the performance motion files sent to ‘Grunt’— Guaranteed Rendering of Unlimited Numbers of Things— a renderer designed by technical director Jon Allitt to render many thousands of agents on a single processor. “Grunt is basically an A-buffer renderer,” explained Allitt, “which means that the information it is rendering can arrive at any time in the process. It doesn’t need to start at the top and work its way down. RenderMan needs to know a lot about a scene before it starts to render it, and then it works from the top left corner down to the bottom right. Grunt can throw the guys in there in any order it finds them, which means that we don’t have to store information about the agents any longer than we need it. We only maintain the picture as it is being pulled up.

“Basically, the renderer has a list of all the agents that we want to render for a scene, and the motion data of the frame that it wants to render, and it says: ‘Okay, I want this guy now.’ So it figures out who he is, what he’s made out of, builds him up on the fly as it is rendering, and says, ‘Okay, he goes here.’ It renders him and then moves onto the next one, who might be standing on the other side. We build up the image from the guys that are closest to the camera to the ones that are furthest away; so any pixels covered by closeup guys don’t need to be rendered for the further-away guys.”

The individual appearance of each agent was also determined at render stage. Massive would generate a random number for each of several physical characteristics— such as height, weight and costuming— and assign those numbers to each individual agent. “Theoretically,” said Allitt, “every agent could look different. It wasn’t practical to do that, but we did try to put as much variation into the geometry as we could, so everyone wouldn’t be a clone of the guy next to him. The Massive system generated the random numbers and scaled the character inside the simulator, which modified its motion. The same information then went through the renderer, so it could build a guy that was exactly the same size.”

A set of sliders served to morph various characteristics from one appearance to another. There were sliders to create different armor and helmets, sliders to control height and girth. Colors, in contrast, were controlled by shaders incorporated in Grunt. A procedural quirk of some of the shaders enabled the character’s costume to appear dirtier as a scene progressed.



To contain render times, the prologue battle scenes featuring 80,000 agents were split into groups of 15,000 to 20,000, and each group was rendered separately. Renders consumed between two and four hours for each group, with the entire prologue sequence rendered in just over a week.

At the gate to the Mines of Moria, the fellowship is attacked by the squid-like Watcher, one of several computer generated creatures created for the film. After drafting designs on paper, Weta Workshop sculpted large-scale, highly-detailed maquettes, which were then scanned with a sophisticated hand-held laser scanner. Using 3D data derived from that scan, the Weta Digital creature team created digital models for animation.

Finally, the Massive elements were composited into live-action, miniature or virtual backgrounds. “We found there was a certain scale of screen size for the Massive agents that worked quite well in compositing,” stated John Nugent. “We might have a row of live-action warriors four layers deep, shot on bluescreen, and behind them, on into infinity, would be the agents, who looked no different from the costumed performers. We put them together with all the normal layers of atmosphere, such as smoke from the battle. We also rendered shadow passes that we could integrate with the ground and the live-action performers.”

Nothing Real’s Shake formed the backbone of compositing for Weta, in part because of its graphical user interface that enabled compositors to accomplish in minutes what would have taken hours. “We were able to access all the processors in the building and kick our renders off,” said Nugent, “and within minutes we would have full, 2K-resolution comps completely rendered and available to load up and look at. If a supervisor asked for some changes, the compositor could kick off a render and have a new version available for review up to three times a day. With that, of course, comes a double-edged sword of infinite changeability. But everybody realized they needed to lock things down and move on because there were so many components to the composites— layers of miniatures, CG elements, matte paintings and environmental components.”

The prologue battle ends when the Gondorian ruler, Isildur, slashes the fingers from Sauron’s hand — achieved as a practical effect— and takes possession of the powerful ring. As Isildur grasps the precious object in the palm of his hand, the ring shrinks to fit his finger and a hidden inscription glows to life. This and other ring effects were accomplished with a computer generated version of the prop, an approach taken up only after other means of visual effects trick-ery had been attempted.

“We did a shot very early in the show,” noted Wayne Stables, “which was the lettering appearing on the ring as Frodo held it. Originally, we’d created 3D lettering, which was then matchmoved to the physical ring. But it was almost impossible to get this lettering to stick to the ring, because it was so shiny. So when we got to doing more of these shots, I suggested that we replace the physical rings with CG rings— do the whole thing in CG, so that the textures and writing would stick to it. It was easier to matchmove a CG ring to someone’s fin-ger than it was to matchmove the inscription onto the ring. So we replaced the physical rings with CG rings in all



For wide views within the Mines of Moria— and in many other instances throughout the film— ‘little people’ scale doubles, often in masks or appliance makeups resembling the principal actors, stood in for the hobbit characters. A foreground mine interior set, built by production designer Grant Major, was extended into the distant background

but one of those shots— one where you see the ring lying on the ground. That one was static anyway, and there was a lot of smoke moving across the

through miniatures. Both full-scale and miniature sets were designed to reflect the rough, angular, stone-based dwarf culture.

foreground; so it was easier to anchor the lettering to that.” The lettering itself was accomplished by rendering a portion of the ring with a glowing, fiery texture, then using 2D lettering as a matte that sat on top. “Our compositors layered those two elements together, and used that matte to bring the writing through.”

Unable to resist the power of the ring, Isildur ignores the pleas of elf leader Elrond (Hugo Weaving) to throw it into the fires of Mount Doom and thus destroy it. With the subsequent death of Isildur, the ring falls into the hands of the creature Gollum, then lies dormant at the bottom of a pond, where it remains until it is discovered by Bilbo centuries later.

The film moves from its expository prologue to Frodo sitting under a tree in the quiet and peaceful Shire town of Hobbiton. “I think Tolkien was influenced by the encroaching march of industrialization on rural life,” related Alan Lee, “and so he created Hobbiton as an idealization of the rural English life he remembered.”

Taking off on Tolkien’s eighteenth-century England motif, Grant Major and his team erected Hobbiton interiors on the Weta soundstages, and built full-scale village exteriors within the farmlands of Matamata, a North Island area not far from the production’s Wellington base. The exterior build took place a full year in advance of shooting so that the buildings and landscapes could become convincingly overgrown with foliage. “It was absolutely necessary to have a year’s growth to give it an established, lived-in look,” said Major. “Hobbiton had to look as if it had been there hundreds of years— and that required layers of landscaping, timed so we’d get spring flowers and grass growing up through the hedges and around the hobbit-hole façades. Fortunately, we’d started the design process early enough so we had time to do that.”

In addition to extensive landscaping, Hobbiton had hobbit holes built into hillocks, with circular doors able to swing in so ‘little people’ extras could enter and exit. A two-mile road also had to be built to allow crews and equipment access to the remote location. So complete was the Hobbiton location build, few digital enhancements were necessary, other than removal of small outbuildings and telephone poles.

Populating Hobbiton are hobbits, creatures which, according to Tolkien, stood just over three feet tall, inspiring the trilogy production company name: ‘Three Foot Six Limited.’ Creating the illusion of differentlyscaled characters— the diminutive hobbits, the slightly larger dwarves, and the human-sized men and elves— was a paramount concern throughout the production, particularly in light of Jackson’s decision to use little people performers as stand-ins and as background characters only, with principal characters portrayed by average-sized actors. “I believed very strongly that Tolkien wasn’t thinking of little people when he was writing about hobbits,” Jackson said, “and when I read the book, I never imagined them with little people proportions. Also, from a practical point of view, going with regular-sized actors made my casting options much broader. We never thought seriously about doing the hobbits any other way.”

Kiwi ingenuity again came into play in determining techniques— some old, some new, some a new take on an old idea— for dealing with the film’s scale issues. After some consideration, production

settled on a scaling ratio for the hobbits based upon Elijah Wood's real height and Frodo's desired height. For the sake of simplicity, that one scaling ratio was applied across the board, to all the hobbit characters, regardless of the heights of the actors portraying them— although there was little disparity in the heights to begin with, as Jackson had purposely cast hobbit actors who were all roughly the same size. Even though dwarves needed to be larger than hobbits, the hobbit scaling ratio sufficed for them, as well, since John Rhys-Davies and the other actors hired to play them were the appropriate number of inches taller than Wood.

To address the movie's scale issues, Jackson had commissioned a photographer to capture stills of a very tall stand-in and a very short stand-in together, from every conceivable shooting angle, early in preproduction. "We studied those stills," recalled Jackson, "and determined how we could achieve all of those different angles. 'Okay, in this shot, we're looking past the shoulder of the big person, down at the small person— that could be an actor standing on a box with a high camera looking down, or it could be a tall stand-in wearing the right wig and costume.' Then we'd move on to the next still. We devised this bible of how we would achieve any conceivable shot; and then, while we were shooting, we would constantly mix up those techniques to keep people guessing."

One standard technique was to shoot actors motion control against bluescreen, then scale them and composite them into the live-action plates. "We would do a motion control camera move on one actor in a scene," explained John Nugent, "scale that camera move in the computer, and shoot that scale move on the other actor against bluescreen. Then we would composite the blue-screen actor back in with the first principal actor."

In other cases, hobbit scale was achieved by placing actors next to oversized props— sometimes even over-sized grasses and leaves— or by duplicating entire sets, one scaled to human size and a second scaled to hobbit size, and shooting them separately. "The production actually built two identical sets for the inside of Bag End, Bilbo's house, for example," said Nugent, "but each was scaled differently— there was a small set and a big set. So if a shot was going to feature Gandalf, they would put Ian McKellen in the small set and shoot him one for one, with Ian Holm shot bluescreen and composited into the shot. Or, if that character didn't have to face front, we could have a scale double there, with the camera just looking over his shoulder."

For shots where the scale doubles would be seen head-on, but from a distance, their resemblance to the principal hobbit actors was enhanced by silicone masks built by the Weta Workshop. To assist the Workshop in producing a mask, the digital department scanned the faces of the little person scale double and the hobbit actor, shrinking the actor's face in the computer until it fit as closely as possible onto the double's face. "We sent that digital file out to a firm that paper-laminated the actor's face at that scale," said Richard Taylor. "We then took a silicone mold off of that, and poured a plasticine replica, which was carefully detailed up and cored onto the original scale double's core. We eventually wound up with a prosthetic that perfectly fit the face of the scale double, but was a replica of the actor." To get some movement out of the masks, some were fitted with radio-controlled, servo-driven mechanisms, the servo-pack hidden beneath a wig.

Production also employed Workshop-built posable hobbit dummies and scaled-up suits with puppeteers inside. "We had five-foot-tall performers inside nine-foot-tall animatronic suits," Taylor stated. "They were made so that whatever the performers did with their bodies, the suits would

replicate that movement. We managed to build sets of stilts that very successfully replicated the movement of the human ankle. The performers' bodies fit into the torsos of the suits, and their hands reached down to the suits' elbows. So they could drive the coarse movement of the arms, while the subtle movements of the wrist and fingers were driven through servo mechanisms built into the forearms." The five suits produced by the Workshop were made of kevlar and were padded so that if the performers fell off the stilts, they would not be injured. Silicone heads were dropped onto the heads of the performers to top off the effect. The suits were used mainly for the sequence at the Prancing Pony, in the village of Bree.

In some instances, very tall extras were used to make the other actors in a given scene appear hobbit scale. One extra, Paul Randall— nicknamed 'Tall Paul'— saw a great deal of screen time. "He was a very big guy," said Taylor, "very fit and healthy, and he did most of these kinds of shots. He was outfitted in Gandalf's makeup, beard, robes and wide-brimmed hat to make Elijah Wood or Ian Holm look hobbit-scaled, for example— but he did other roles, as well. He acted almost every role in the film, and he did a beautiful job."

In-camera forced perspective was also utilized. One classic forced-perspective illusion had Gandalf working the reins of a horse-driven cart, with the diminutive Frodo seemingly sitting alongside. In reality, the passenger-side seat was set some feet back from the driver's seat, making Elijah Wood look Frodo-scale to the camera. "The seat that Gandalf sat on was much closer to the camera, and the seat Frodo sat on was much farther away," Nugent related. "But if you stood where the camera was viewing, they lined up as if the two seats were a single bench."

Production improved on these in-camera scale effects, which required a locked-off camera, through a slaved motion control system that allowed for camera movement. The system was built by key grip Harry Harrison from a design by Brian Van't Hul; but the theory behind the slaved motion control setup was first proposed by Bill Taylor of Illusion Arts, who had visited Jackson in New Zealand during the preproduction period to discuss his possible involvement in the film.

"We were talking to Bill about forced perspective," Jackson recalled, "and he said, 'You know, I've got a theory that I've never been able to test— an idea of how you could do moving forced-perspective shots.' Obviously, the problem with the Darby O'Gill-style forced-perspective method is that once you move the camera in any direction, it ruins the illusion you've created in two dimensions. The illusion relies on staying in 2D— and if you move the camera, the real depth is exposed. Bill's idea was to move the camera with a motion control rig, and at the same time, move one of the characters on a slaved motion control rig— so the camera and the character would be moving in exactly the mathematical proportion that they should to the camera. So Bill dropped this idea on us, went



Deep within the cavernous mines, the fellowship discovers the long-abandoned dwarf city of Dwarrowdelf. Though, overall, Peter Jackson preferred creating his expansive Middle-earth environments using miniatures, Dwarrowdelf— with its repeating rows of columns, extending into infinity— lent itself to an all-digital construction. The digital set also allowed for sweeping camera moves. In an example of yet another scaling technique, the fellowship performers were shot separately against bluescreen— usually with a motion control move, scaled appropriately— then composited into the CG Dwarrowdelf set.

back home, and we did some tests immediately and found that the technique worked amazingly well. We could dolly in a lateral sideways move, or we could dolly in or out, and the relationship of the forced perspective would stay the same, as long as one of the characters was moving on a rig slaved to the camera.”

For a shot featuring Frodo and Gandalf within the same frame, for example, Elijah Wood would be placed on a platform farther back than Ian McKellen to make him appear smaller; but that platform also would be slaved to the motion control rig so that as the camera dollied in on McKellen, Wood would move forward at the correct rate to proportionally alter the spatial relationship between him and the camera, and thus sustain the illusion of disparate size in the two characters.

The slave setup was used for a scene in which Bilbo and Gandalf share tea at a table in Bag End. Separate halves of two differently scaled tables were placed at a distance of about three feet and lined up to appear as one in camera, with a tablecloth and variously scaled props hiding the join. As the camera moved laterally, the table at which Ian Holm sat dollied in scale with the moving camera. “In a preproduction test for this shot,” Van’t Hul remarked, “we started getting tricky, having them appear to clink their tea cups together, even though they were actually three or four feet apart from each other. In the final shot, Bilbo steps over to the table and pours water into a teapot.”

Ultimately, the variety of the scale techniques in the film was the secret to their success. “The way the illusion was achieved changed from sequence to sequence,” commented John Nugent, “and sometimes from shot to shot within the same sequence. We would switch back and forth between oversized sets, undersized sets, forced perspective, scaled camera, scaled composite or scaled double. With so many different techniques, even the most effects-savvy moviegoers would be hardpressed to figure out how the scale effects were achieved. Just when you think you’ve got it figured out, another shot pops up that was done completely differently.”

Upon his arrival in Hobbiton, Gandalf discovers its citizens happily preparing for Bilbo’s birthday celebration that night—a celebration that includes fireworks set off by the mischievous Pippin and Merry. Celebrants duck as a rocket explodes from a tent, then flares into the shape of a dragon that swoops over the village before erupting into a massive pyrotechnic display in the night sky.

To choreograph the fireworks dragon, the animation team worked with a CG model, built like any of the other digital creatures in the show. “Because it was a model,” observed Randy Cook, “there was the impulse to animate it to look like a dragon, not dragon fireworks. The animators were so good, it kept coming out looking like creature animation—they almost couldn’t make it look as phony as it needed to be in order for it to look like a firework. We had to keep simplifying it more and more; and we finally stripped it down enough to make it look like a magical firework and not a creature.”



Hoping to avoid a run-in with the Moria orcs known to inhabit the mines in great numbers, the fellowship proceeds with stealth and caution through the ancient dwarf city. For wide or extremely high-angle shots, in which the virtual camera was some distance from the characters, Weta Digital inserted a computer generated fellowship into the Dwarrowdelf environment. Highly accuratedigital replicas of the characters were used throughout the film, sometimes almost full-frame.

After the animation was completed, smoke trails were added to all the fireworks shots to make them look less computer generated, and to better integrate them into the environment.

In the aftermath of the party, a troubled Bilbo takes his leave of Hobbiton, reluctantly bequeathing the ring to Frodo, who hides it while Gandalf departs in haste for the Gondorian city of Minas Tirith, where he pores over old books and manuscripts seeking answers as to the ring's origin and mysterious, corrupting power. When he returns, Gandalf bears the grim news of the ring's true identity as the one ring that will lead to the ascension of Sauron's evil spirit and, ultimately, the destruction of Middle-earth.

To conceal the ring from Sauron's dark emissaries, Frodo leaves Hobbiton, traveling with Sam, Merry and Pippin to the village of Bree where they are to rendezvous with Gandalf at the Prancing Pony Inn. In the course of the journey, the hobbits are hunted by dark riders on black horses—men who once possessed the rings of power, but have now become evil spirits under Sauron's control. Frodo escapes death at the hands of these Nazgûl— or 'ringwraiths'—only through the intervention of Aragorn, a warrior and ancestor to the royal family of the now fallen Gondor race of men.

At the Prancing Pony, Frodo inadvertently slips on the ring, becoming instantly invisible and entering an alternate reality the filmmakers dubbed 'wraithworld.' "Peter wanted a scary 'twilight vision' into which Frodo finds himself," stated John Nugent, "a high-frequency, turbulent look where the edges of things are tattered and frayed. He described something similar to heat distortion, except that it would be a 3D effect in which objects and people would be smeared and whipped around as if in the center of a vortex."

Three Weta Digital staffers were instrumental in arriving at the wraithworld effect, which would recur throughout the film. 2D lead Charles Tait, initially tasked with devising the look, worked in conjunction with 3D lead Colin Doncaster in emitting 3D particle streams off of a 2D plate. That imagery was then subjected to a software called IMX, developed by Shane Cooper. "IMX gave the compositor the ability to take these animated, whipping particle streams and smear the images," Nugent explained. "We left Elijah Wood's face untouched to create the impression that the disturbed images are what Frodo is seeing, and that we are in the wraithworld with him."

"IMX plugged into Shake," elaborated Jim Rygiel, "and gave us the 3D effect. Rather than just getting a kind of tattered, torn look on an image, we could track all of the elements—Frodo and the background plates and anything in the foreground—in three-dimensional space. So as the camera moved around, we would emanate particles in 3D space from these tracked plates. The particles would be emitted in 3D, and would actually streak the stuff in 3D. So the effect was different than simple streaking of the image; it would start from the back and streak things that were behind it, and then it would build up on top of that. It gave a lot of dimension to the whole thing."

Hiding in the village, under the protection of Aragorn, Frodo awaits Gandalf's promised arrival—but he never appears. The wizard, who had journeyed to the walled fortress of Isengard to seek the aid of his old friend and fellow wizard Saruman, has found his colleague transformed with hunger for the ring and its power. When Gandalf declines to join Saruman, now in collusion with Sauron, he is imprisoned atop the Orthanc tower.

Alan Lee had done an illustration of the tower for a ten-year-old edition of *The Fellowship of the Ring*, and Jackson based his depiction on that art work. “I totally loved Alan’s painting of Orthanc,” said Jackson, “and that’s what wound up in the film. The only difference is that Alan had painted only the base of it, about the first thirty feet. It drove me crazy— I stared at that painting for a year, wondering what the rest of the tower was like. So as soon as Alan arrived in New Zealand, I said, ‘You’ve got to draw the rest of that tower for me!’”

Wide establishing shots of Isengard were realized through a variety of miniatures— one representing the tower, another the above-ground exteriors, and others the open caverns below. The exterior miniature consisted of more than a thousand pieces of individually fashioned industrial architecture, such as water sluices, crane arms and crushing machines. “The idea is that the orcs are defoliating that part of the world,” explained Richard Taylor. “They’re chopping down trees, throw-ing them down into the pits where they are chopped up and fed into the fires that are fueling the furnaces. Those furnaces are smelting the iron ore to generate armor for Saruman’s army. We figured out all the water that would have to be sluiced from the mountains to quench the steel, the supply of iron ore on little push-carts, and the practical reality of the equipment that would be needed to actually do these jobs.”

The below-ground settings evoked a similarly industrial feel. “We shot the scenes below Isengard on a huge set in the studio,” explained Taylor. “It consisted of hundreds and hundreds of pieces of working equipment and ladders. John Howe had the idea that orc power is used for everything there. So there are these massive wheels that aren’t turned by water or steam, but rather by orcs walking inside them, like hamster wheels. We built a large number of working versions of those, all driven on stepper motors.”

The Orthanc tower miniature was one of the first setups of the show for the miniature photography crew. “It was a beautifully carved piece, made to look like obsidian,” observed Alex Funke. “It was supposed to be very shiny— shiny enough to reflect the surrounding trees. So we went out to the location where they shot the live-action material and photographed stills of all the trees there, then made large color xeroxes of those to build a physical cyclorama around the miniature tower. We had sky reflections on the upper part of the model— created by putting a white panel over the top and then lighting it to the proper color— and green reflections on the lower part.”

A fierce battle between Gandalf and Saruman transpires within the Orthanc tower. Peter Jackson took a physical, low-tech approach to the sequence. “I don’t particularly like wizard battles,” Jackson acknowledged. “I have an immediate bad reaction to images of blue lightning bolts being fired out of fingertips, flashes of smoke and all of that usual magical stuff. So I always had some trepidation



Digital doubles for hobbit Sam Gamgee and Gimli demonstrate the level of detail incorporated into the CG human characters. Puppet construction began with a full-body scan of a single human subject. From the data thus obtained, Weta crafted a generic model that could be stretched or compressed to produce a suitable match for each actor requiring a digital double. Facial features were replicated by scanning the made-up actors in a number of different expressions. Highly realistic hair and cloth simulations were also achieved. Depending on the shot, puppet choreography was created either through motion capture or key-frame animation.

about the wizard fight. I thought it would be funny, and more interesting, to see two old guys just beating the crap out of each other. So I kept it deliberately physical and low-tech.”

Steve Ingram devised a number of clever physical rigs to spin and fly the actors, or, more often, their stunt doubles. “Christopher Lee was 78 at the time,” Jackson stated, “and so he was limited as to what he could do. Ian McKellen was able to do more, but we didn’t want to put him through the mill, either. Fortunately, they were both playing characters with long hair and big beards, so stunt-doubling wasn’t too difficult. We did it all with these physical rigs, with only a little bit of painting out wires required.”

Late in post— with Weta Digital’s workload mount-ing— the production farmed out twenty shots to Animal Logic, an Australian effects house, among them views of Palantir, the black orb through which Saruman communicates with the spirit of Sauron. “Peter’s idea,” said Animal Logic visual effects supervisor Chris Godfrey, “was that it would appear like an old-age Internet device. It was always meant to have a life of its own, even in its noncommunicating state. On the set, they shot a black obsidian ball, with the idea that something would then be tracked over the top of that. We built up layer upon layer of images, with the outside layer being a cloud effect. We built up texture maps of sparks and spires in a whole range of colors— blues, oranges, reds. We also had to pull reflective colors from outside and blend them in so the ball looked as if it was part of the scene. Our art director, Ian Brown, developed the look for that; and the first time we showed it to Peter he was blown away with it. So we got it on our first try, only having to go in and refine it at that point.”

When Saruman passes his hand over the ball, Palantir reacts with changing colors, and the Eye of Sauron starts to appear. The flaming orb, seen in flashes throughout the film, was created by Weta, after a lengthy and arduous conceptual phase. “The Eye of Sauron was difficult,” stated Jim Rygiel, “in that no one could get a grasp as to what it actually was. There were a lot of sketches done, but they were all different. What was the eye supposed to be? Was it a menacing eye? Did it look like a real eyeball? Even Peter spoke of it in very vague, conceptual terms— ‘It needs to be kind of fiery.’ After trying several different looks, we came up with a cat’s eye, which, to me, is the creepiest-looking eye of all. But even once we’d decided on that, we went through many different iterations. The Eye of Sauron had the smallest role in the film, but it took the long-est to conceive.”

The Eye of Sauron was finally achieved by applying shaders and particles to a piece of taurus-shaped digital geometry. Live-action flame elements shot with a high-speed camera were applied to particles surrounding the geometry to achieve the fiery look. “The iris texture came from shooting dry ice dripping off the edge of a table,” explained Gray



In a chamber deep within the caverns of Moria, the fellowship is set upon by dozens of orcs and a giant cave troll. The resultant fight with the computer-generated troll was first worked out in previz, using a virtual reality technique that enabled Peter Jackson and animation director Randy Cook to move around within a digital set, complete with choreographed troll and key combatants, and capture the action with a handheld virtual camera. Actions established in the previz formed the basis of both the live-action shoot and the final computer animation. Digital set extensions created a ceiling for the partial stage set on which the live actors performed.

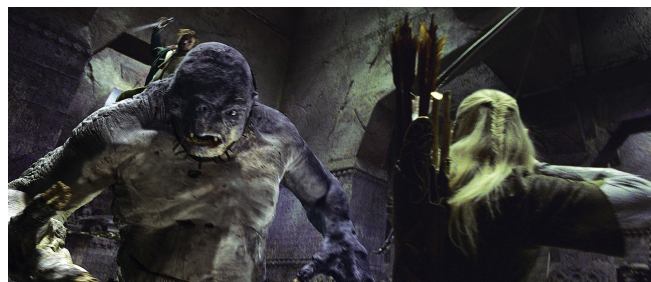
Horsfield, who developed the concept, “and then treating that footage and squishing it up into a sphere. Other textures came from elements of the sun shot from underwater, with all the refraction happening as beams of light came straight at the camera— that was used for the ethereal glow around the outside of the eye. All together, there were about eight particle system layers and a number of different live-action layers making up the eye.”

Imprisoned atop the Orthanc tower, Gandalf summons a moth and whispers instructions that will lead to his escape. The insect is first seen in a nighttime Isengard flyover— the camera follows the winged creature as it flits over the caverns, then up toward the top of the tower. The establishing shot was achieved with a massive, thirty-fifth-scale circular fortress set. Too large to be accommodated by any of the stages, the fortress miniature was built and shot outside.

After a sixty-foot-diameter concrete perimeter wall was poured, Workshop crew members attached a pre-fabricated urethane wall. “It was built in four-foot sections,” Richard Taylor elaborated, “which fit together and interlocked perfectly to form this perimeter wall. Then we bulldozed out 28 massive holes. We had pre-built detailed orc caverns, which were made out of urethane foam sprayed into tinfoil tubes, and those were dropped into the holes outside.”

Another prefabricated component of the miniature was a large mountain piece, anchored down with massive cargo containers to withstand the region’s not infrequent eighty-mile-per-hour winds. The dirt that had been dug out of the holes was also poured inside the urethane mountain form, further stabilizing it. Finally, the Orthanc tower miniature was dropped into the middle of the circular fortress.

Once all the different components of the Isengard miniature had been assembled outside—including the subsurface cavern chambers— two large spray units applied a rigid polyurethane over the entire surface. “That put a two-millimeter membrane over the whole circle,” said Taylor. “As I sprayed, a team of people followed behind me, throwing in different textures. Sand, up-rooted trunks, bits of old foliage and industrial equipment were literally planted into the wet urethane, which would set in about six seconds as we were spraying. So by the time we were finished, we had this huge membrane that had all the equipment embedded in it, like toppings on a pizza. Then we painted the whole thing.” The miniature was plumbed for smoke and water effects, and, at considerable cost, was fitted with submersion pumps so that rainfall could be pumped out quickly and easily— although, unexpectedly for the season, the anticipated downpours never materialized. Filmed motion control by effects cinematographer Richard Bluck, the Isengard set survived successfully in wind and sun for the entire four months required to shoot it.



Digital doubles were employed for dynamic actions in the troll battle that were too dangerous or required too much interaction with the digital beast to successfully capture using live actors or stunt doubles. In the final moments of the fight, digital replacements for hobbits Merry Brandybuck and Pippin Took leap onto the troll’s back, as the elf Legolas, a live character, takes aim with his bow and arrow. Digital arrows were tracked to actor Orlando Bloom’s mimed actions to sell the illusion of Legolas’ extraordinary skills as an archer.

A later Isengard shot, in which the camera moves down into the caverns, hooked up a motion control stage shot of the thirty-fifth-scale tower to a fourteenth-scale cavern— set on its side and shot horizontally for ease of camera movement— and finally to a live-action crane move that ended on orc workers hammering out swords. Orcs in this shot were portrayed by the actual Weta Workshop blacksmiths who had crafted all of the swords used in the film.

Miniature photography plates from the outdoor Isengard shoot were digitally augmented for the establishing moth shot. “Peter wanted this huge camera move,” commented Alex Funke, “with the camera swooping in over the wall and then up to the top of the tower. But it wasn’t possible to do the camera move all the way to the top of the miniature tower, because we couldn’t go that high with our crane. So, in the final shot, we fly in on the thirty-fifth-scale miniature, over the wall, and then start to climb the tower, hooking up to a digital model for the upper half. Then, as we come up to the top platform, it cuts to Gandalf sitting in a live-action, full-size set— basically a platform and the bottom two meters of the spikes that crown the tower, raised up on a blue floor. That shot goes from miniature to digital set to full-size live set, all in one continuous motion control move.”



Having slain the hulking troll and routed its orc masters, the fellowship flees through the forest of stone columns as thousands more orcs emerge from the bowels of the mines in pursuit. Bluescreen elements of the actors, together with digital orcs created through Massive, were composited into the CG Dwarrowdelf set. A library of motion-captured actions provided the basis for the animation of the crawling, climbing, running orcs.

The flyover was composited by Mark Tait Lewis, who had to deal not only with the live, digital and miniature fortress and tower elements, but also with the CG moth, CG orcs and atmospherics. “There were just a lot of little elements that had to be put down in the caverns themselves,” noted Jim Rygiel, “things that couldn’t be shot on a miniature, such as interactive lighting and smoke plumes pouring out of the holes from underground. So that was a multilayer composite that had to track— and there was a lot of massaging.”

The computer animation of the moth also required a bit of massaging. “We went around a bit with the moth,” said Adam Valdez, “because he was sort of a supermoth, able to fly a thousand miles per hour and reach the top of this huge tower. We had to walk a line between complete reality and dramatic performance. The most fun part of the shot was trying to create the feeling that this little moth was answering a call. It wasn’t supposed to look as if he just happened to be fluttering by and Gandalf captured it. We had to make it clear in the animation that he was there intentionally to have a chat with Gandalf and see what was going on. Ian mimed the whole action, without anything in his hand.”

The moth returns later, followed by the eagle Gwaihir who bears Gandalf away from the tower on his back. The eagle, too, was computer animated, its arrival by Melanie Cordan and its exit by Stephen Buckley.

While Gandalf makes his escape, Aragorn leads Frodo and his companions— pursued by the Nazgûl — out of Bree and toward the ruins on Amôn Sul where they camp for the night. But the dark riders

surprise the group; and in the battle that ensues, Frodo is stabbed by a Morgul blade. The wound threatens to transform Frodo into a ringwraith, which he momentarily sees as withered, ashen-faced spectral forms. The spectral ringwraiths— heavily image-processed in postproduction— were created with Weta Workshop prosthetics on live performers.

The beautiful elf warrior Arwen Undómiel (Liv Tyler) arrives to offer assistance, stepping out of an intense magical glow that surrounds her. Animal Logic supplied the glow effects for Arwen's first appearance, which had to blend with Weta's more subtle glow effects in subsequent shots. "We had to make the first glow on Arwen very heavy," explained Chris Godfrey, "because what they had actually shot was a stunt girl in the wrong outfit and with the wrong hair, which didn't coordinate at all with the following shots of Liv Tyler. So our job was to supply that continuity by putting this very heavy glow effect on her. We did it in Softimage with Mental Ray, writing an additional tool to get the rays to come out from behind her. We built foliage as physical objects, so the light rays would appear around a tree, behind a bush, and reappear around another bush. All of that was done by creating simple 3D objects."

Bearing Frodo on her magnificent white stallion, Arwen races ahead toward the elven city of Rivendell, hoping to arrive before infection can take hold. But the relentless ringwraiths pursue them to a river, a site called the Ford of Bruinen. Live-action for the river scene was filmed at Skippers Canyon, a remote South Island area near Queenstown that proved to be one of the most challenging locations of the show. "The only way to get our equipment in there was by helicopter," said Barrie Osborne. "We also had to bring in nine racehorses by trail. Throughout, we picked the most spectacular and appropriate locations we could find. Rather than letting the difficulty or ease of getting to locations dictate where we filmed, we'd go for what we thought would be most impressive on screen— then figure out a way to use those locations in a reasonable fashion. If it meant going in with a small crew by helicopter, we did that. If it meant building roads to transport our people in, we did that."

After navigating her horse across the river, Arwen faces the ringwraiths approaching the opposite bank and summons elven magic. Suddenly, the river starts to rise, taking the form of watery steeds that crash down on the dark riders and sweep them away. The six-shot sequence was handled by Digital Domain, with Mark Forker serving as visual effects supervisor.

The water horse effects drew upon Digital Domain's previous experience with water simulations— notably in *Titanic* and *O Brother, Where Art Thou?*— but also featured a new and complex blend of live elements, 2D effects and 3D character animation. "We knew that the sequence was going to require a combination of virtually every kind of technique that you could think of in visual effects," observed digital effects supervisor Kelly Port. "What we didn't know was how much was going to be CG and how much was going to be live photographic elements."

To clarify the sequence's design, Forker, Port and Digital Domain producer Kelly L'Estrange traveled to New Zealand to meet with Peter Jackson and review existing footage. A Weta previz gave them a feel for the scene's timing, while three conceptual paintings illustrated the look of the water horses. Film shot at a New Zealand dam burst provided real-life reference. "If you squinted your eyes at the reference footage," Forker recalled, "you could almost see horses emerging from the patterns in the water, with these crests appearing and diminishing. Peter wanted the water horses to be so subtle

that the first time an audience saw them, they might think, ‘Wait, what was that?’ They had to be very ephemeral, emerging and then disappearing.”

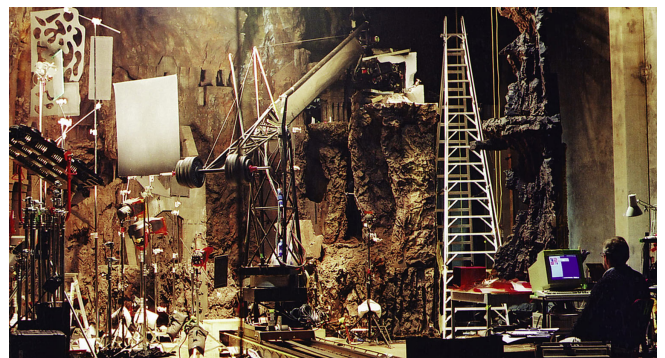
Inspired by the dam footage, the Digital Domain team returned to Los Angeles and began seeking out further reference as a means of experimenting with the balance of filmed and CG elements. Forker supervised an element shoot at Niagara Falls, filming turbulent water from above and below the cataract. Forker and his crew also staged elements at Digital Domain, dumping tanks of water from a height of forty feet, shooting at 72 and 96 frames per second to enhance the scale. To capture effects of spray taking the shape of a horse’s head, technicians hung a black-painted dummy horse head from its muzzle and photographed it while pouring streams of tiny glass beads over it. Luminancekeying the beads gave digital artists a physical particle simulation to add to their water horse composite.

For shots prior to the riders being felled, Weta supplied elements of ringwraiths charging at camera. “That was a fun day,” said Brian Van’t Hul, who shot the footage. “The stunt riders were really good; but it still came down to me looking through the viewfinder, standing waist deep in water, a grip behind me, spotting me to push everything out of the way in case the horses got too close. Every time, water sprayed up on me and I would feel my shoulder being hit by a horse going by— but we got some really cool closeup stuff.”

At Digital Domain, Darren Poe’s compositing team split selected horse performances from six different takes, then rotoscoped and reassembled elements. The violent motion of horses being snatched up by the water, impossible to stage with live animals, was then created as 3D character animation using digital models of ring-wraiths and their mounts supplied by Weta. Kelly Port’s team converted those NURBS models to a polygonal format, as favored by Digital Domain’s in-house production pipeline, and developed computationally intensive cloth dynamics to emulate the effects of the ringwraiths’ heavy fabric robes being hit by torrents of water.

Piotr Karwas and Bernd Angerer then used key-frame animation to depict horses and riders being sucked into the churning river. “We played with a lot of variations of horse and rider movement,” said Forker. “Some went head over heels. Some slid across the top of the water towards camera. Some were buried under the waves. One rider in the center of the group went under until the last couple of frames of the shot, then he popped back up and hit the camera. Each rider was doing something quite different.”

Karwas and Angerer also established the underlying movement of the charging water horses using a combination of key-frame animation and live horse motion studies. Markus Kurtz brought the underlying anima-tion into Voxel-B, a volumetric modeling system written by Alan Kapler as a plug-in



The fellowship makes its way to an enormous stone stairway leading to the bridge of Khazad-dûm, which extends over a fiery chasm. Weta Workshop built a detailed miniature cavern set, complete with stairs and bridge, for the pivotal sequence. Even at fourteenth scale, the set filled an entire warehouse stage. The Workshop crew coined the term ‘bigatures’ to describe the massiveminatures fashioned for the film, many of which were larger than standard full-scale movie sets. All miniature photography for the show was supervised by visual effects director of photography Alex Funke.

to Houdini. Doug Roble then tied the volumetric animation into Fluidism, a fluid simulation program that produced a dynamic flow of water through the water horses while the main thrust of water cascaded about them through the canyon plates. “Voxel-B was an efficient way to render the entire 3D volume,” remarked Forker, “because it represented the look by computing cloud point densities and then outputting ‘slices’ of the image, creating information in layers so we would only render what was viewed from camera.” Adding to the detail, Kurtz, Dan Lemmon and Greg-Duda generated layer upon layer of animation effects, shading and adding highlights to bring out subtle equine facial shapes in the surging apparitions.

Shots were assembled in the studio’s proprietary Nuke system, tracking fluid simulations, water horses and ringwraiths into plates, adding glimmers of specularity to create wet looks on the riders, blending live spray and splash in 2D, and rotoscoping Arwen and Frodo as foreground elements. The sequence was in production at Digital Domain for eleven weeks.

Recovering from his wound, Frodo awakens days later in the elven house of Elrond, in the breathtakingly beautiful Rivendell. Although a partial Rivendell set was built less than an hour’s drive from Wellington, at Kaitoke Regional Park, the magical environment still required a number of enhancements, both miniature and matte painted. “For Rivendell,” observed John Nugent, “Peter wanted a grandeur and magic you would never find in a real place. It was also supposed to have trees full of autumnal leaves, which you don’t come across that often in New Zealand. So we embellished the look of the natural environment and extended the city with motion control model elements, matte paintings and live-action elements.”

Weta Workshop modelmakers Mary Maclachlan and John Baster built the Rivendell miniature, a completely camera-ready model with scaled trees and surrounding rock faces. “It was produced primarily in computer controlled router-cut styrene sheets,” explained Richard Taylor, “with urethane rock castings made out of silicone or generic rock molds. Alan Lee played a big part, supervising the coloring of the model to suggest the elves were in the autumn of their years, and nature itself was taking over their architecture.”

Chuck Schuman shot the Rivendell miniature, matching motion control moves on bluescreen elements of the actors. “To give us flexibility,” Alex Funke noted, “the entire set was made on a series of islands on casters, so we could pull them apart and shuffle them around and reposition them. So Chuck was able to arrange the miniature to build the correct background for each particular shot. And since final shots hadn’t really been worked out yet, Chuck shot a lot of material where he broke the set up into layers, so they could generate an artificial perspective shift. It was shot as a lockoff, essentially; but by shooting it in layers, we could take a separately shot foreground piece and move



The dizzying stairs, atop huge stone arches, begin to collapse as the fellowship attempts to descend toward the bridge at Khazad-dûm. A digital set, with crumbling steps, falling rocks and teetering plinth, extended a locked-off miniature plate. For numerous shots in the sequence, the fellowship actors were filmed against a bluescreen and composited into the miniature photography. Other shots utilized digital doubles, animated via data extracted from motion capture sessions of the actors descending stairs on stage.

it in relation to a separately shot background piece, creating a move after the fact.” A dawn lighting scheme was used for the Rivendell miniature shoot, with smoke simulating a foggy mist.

A CG cyclorama was constructed for the more distant backgrounds, made up of scenic unit elements captured in a South Island canyon called Fox River Valley. There, a 360-degree template of stills was photographed, and later mapped onto the CG cyc. Paul Lasaine had originally envisioned a Mediterranean-blue color scheme for Rivendell, but the look changed when the scenic unit met with inclement weather— a common occurrence in New Zealand. “We had to wait three days for the sun to come out,” said Lasaine. “When we could finally shoot, it was cloudy-clear, a misty haze with beams of light coming through. So the look of Rivendell became misty; but I think Peter wound up liking that better than a perfect sky.”

Waterfall plates were also shot after that rainstorm, the worst to hit the South Island in a hundred years. The upside was that, in the storm’s aftermath, the area’s many waterfalls were in full bloom. “When the sun came back out,” recalled Mark Stetson, “we went out with a small crew in a helicopter and shot waterfalls all day long. We’d locate a waterfall from the air, touch down, find a good place to put a camera, and roll off some moving picture footage. It gave us all these wonderful waterfall elements that we could put into the digital matte paintings.”



The signature shot of the Khazad-dûm sequence is a long, arcing camera move that starts behind the fellowship. Foreground characters at the beginning of the shot were bluescreen elements, while the ones beyond were digital doubles. An off-screen hand-off to all CG characters occurs as the camera begins to crane up and over the bridge. Portions of the Khazad-dûm miniature had to be replaced mid-shot with a digital replica, due to bluescreen and miniature motion control moves that failed to match precisely. In the final frames of the shot, the monstrous Balrog steps into view, and Gandalf turns to face it.



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One Rivendell scene, a reunion between Frodo and his friends, takes place on a balcony overlooking the city. The actors stood on a real set piece against bluescreen, and Chuck Schuman's miniature photography was then composited into that bluescreen to provide the city view. Other shots in the sequence follow Elrond walking down a hallway in a full-size set, with miniature views of Rivendell visible in the hall windows. Live-action of Elrond in the hallway set was filmed motion control, which recorded camera dolly moves, as well as camera pan and tilt. That motion control file was then used as the basis for shooting the miniature elements.

Applying camera moves from one setup to another was not as simple as downloading the files, however — especially since motion control often was not used, in deference to Peter Jackson's loose shooting style. Weta Digital's camera department contributed what was called 'technical breakdown,' a vital step in the process of translating camera movement and critical lineup information back and forth between the previsualization, bluescreen, live-action, miniature, motion capture and digital camera setups. "Survey information, on-set notes and motion control data, if any, were collected at every step of the process," explained Brian Van't Hul, "and all of those pieces were routed through the technical breakdown hub, where they were repackaged to suit the conditions and shooting environment of the next element to be shot. In most cases, plates were retracked and new motion data was created to suit the scale and orientation of the next setup."

This new package of information, which included a motion control move, diagrams of lineup measurements, lens information and video assist images, would be sent to Sean Mathiesen or Jake Lee of the camera department, who would then assist the crews in lining up the shots, which often involved re-engineering the space and speed of camera moves. "Technical breakdown allowed us to solve problems and incorporate our postproduction manipulation of the elements before they were shot," observed Van't Hul. "Being able to work through the setup problems in the computer beforehand saved valuable setup time on set, and allowed us to think through each shot's unique problems."

The camera department employed 3D Equalizer for all of the tracking and matchmoving in the show. "3D Equalizer is great," remarked Van't Hul, "and it's getting better all the time. But there's still a certain amount of manual cleanup that has to be done. The computer takes you seventy percent of the way there; but it still gets confused— is that a move or a pan? We have to go in and clean up all of that stuff. It isn't a fully automated process. There's still the requirement for some really skilled people."



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In the case of the Elrond hallway shot, the camera department cleaned up the motion control file and did the technical breakdown, correcting tracking errors made by the motion control system and scaling everything down by a factor of twenty-four to compensate for the twenty-fourth scale of the miniature. That finessed motion control file was then turned over to the miniature photography crew.

All of the Rivendell shots were sweetened with an autumnal glow, achieved in a postproduction digital color grading process. In fact, most of the film underwent color grading, not only to enhance the magical quality of the Middle-earth environments, but to soften the over-harsh New Zealand lighting. The work was undertaken by The Posthouse, a postproduction facility based in Hamburg, Germany. The Posthouse set up shop in a Wellington warehouse, connected to Weta Digital via fiber-link. "This project was so big," stated Posthouse digital color grading supervisor Peter Doyle, "it was essential to have a dedicated facility just working on achieving the look Peter Jackson and Andrew Lesnie had in mind."

Early in the film, Jackson and Lesnie had considered photographic techniques as a means of creating that look. "We tried to think of ways that we could take all the landscapes and environments of New Zealand and push them more toward the Alan Lee/John Howe palette," said Jackson. "The New Zealand lighting is very harsh and bright because we have no ozone layer down here, thanks to North American aerosol cans and that sort of thing. But that wasn't the look we wanted for the movie. We wanted a softer look. I also thought it would be nice to introduce the look of the artwork.

"So Andrew and I talked about how we could do that photographically, using filters and special lighting and only shooting at certain times of the day. But, of course, once we were on the set, any dream of shooting a scene at the magic hour flew out the window. Logistically, it just didn't work. And the day we wanted it to be overcast, it would be sunny; and the day we wanted it to be sunny, it would be raining. All the plans we'd made in preproduction didn't last a day when we got to actually shooting; and so we started thinking of doing a digital grade. It was at that point that we started talking to Peter Doyle and Posthouse."

Supplied with Posthouse specifications, Colourfront created software dubbed Colossus, whose unique characteristic was its ability to not only take a scanned camera negative and change color across the scene, but to assign specific color values to any element in frame. "Almost every shot in the movie had some sort of color vignette applied," said Doyle, "from subtle gradations to pulling background exposure down to give the foreground more emphasis, to swinging a very green forest to more autumnal colors. Peter's brief was to make it look cinematic and 'storybook,' but not treated."

“It was a very flexible, user-friendly system,” added Jackson. “We could control the gamma contrasts, the colors; we could isolate sections of the frame; we could bloom out the highlights on people but not touch the shadows; we could make a sunny day look overcast and an overcast day look sunny—we could do any number of variations in terms of color and grain. I loved it. The platform that Peter developed is one of the greatest tools for a filmmaker that I’ve seen. We went in thinking we’d do a digital grade on forty percent of the film, but we ended up doing a grade on nearly eighty percent. The funny thing is that people are always asking me if we did something to Elijah Wood’s eyes to make them so blue—but that’s the one thing we didn’t touch at all!”

The ubiquitous color grading had a significant impact on the compositing of effects shots, which are typically matched to the non-effects principal photography to ensure they will blend seamlessly. But that benchmark was constantly changing. “We would run into situations where the digital grade had not been established for a sequence yet,” John Nugent commented, “so we didn’t know what to match to. It was an infinite tweakability problem. The director had the ability to change the look of a sequence at any time.”

In Rivendell, under the guidance of Elrond, a nine-member fellowship of two men, four hobbits, an elf, a dwarf and a wizard is formed to journey to Mount Doom and destroy the ring that threatens all of Middle-earth. Wide shots reveal the fellowship at the start of its long journey, passing castle ruins on a hill. The aerial shot had been captured by helicopter, without the aid of a stabilizing system, such as a Spacecam—a piece of equipment subsequently provided by the budget-conscious studio late in production. The result was an unstable plate that required painstaking matchmove work when it came time to add the castle ruins miniature element to the location scenery.

“From a camera tracking standpoint,” stated Brian Van’t Hul, “that was an extremely difficult shot—not only because it was unstable, but because there was a zoom within the plate. With any automatic tracking software, or even if you are doing it manually, the most valuable piece of information is what lens was used. If you don’t have that, you’re dead. The aerial unit that shot this was zooming during the shots, but they only had a rough idea of what the focal length of the zoom lens was. The zoom was kind of subtle—going in as the helicopter pulled out—and the tracking software had difficulty figuring out when one started and the other ended. We were eventually able to lock that one down, but it took a long while.” In addition, the problematic plate also had rotor blades dipping into frame, which had to be removed digitally.



An extended, intense design effort by Weta Workshop was required to develop the look of the Balrog, described by Tolkien as a creature of ‘shadow and flame.’ The final character design was based on an illustration by conceptual designer John Howe. After tests with a physics-based fire simulation proved too render-intensive, the creature’s singular look was achieved using ‘sprites’ – digital particles onto which film images were texture-mapped. For the Balrog’s fiery form, practical flame elements were mapped onto the particles.

Shortly into its journey, the fellowship is spotted by a flock of crows, emissaries sent by Saruman to determine their location. The crows were created through a combination of Massive and key-frame animation. “One of our animators, Chad Moffitt, built up a library of key-frame animated bird cycles,” said Adam Valdez, “just as we would for any other Massive agent. These were flight cycles, banking turns, air-braking with the wings, all that sort of thing. Then Ollie Rankin, one of our Massive TDs, built a bird brain. Each bird had its own autonomous brain; so this wasn’t a case of flying a bunch of particles through the air or coming up with some guiding shapes that all of the birds had to follow. This was pretty close to a bunch of birds flying around. Flocking approaches of the past have involved origination points and target points, and then you approximate the natural movement between those points by various degrees of noise or random factors that get scaled in. But with Massive, once the crows were let loose and flying, we couldn’t stop them until the shot was over. We would run the simulation and the birds would do what they were going to do. It was a real challenge, because the animators had to think how they could limit the birds, staging-wise, for particular shots. There was a shot where all the crows flew down into Saruman’s cavern, for example. For that, John Allitt created what you might call waterslide tubes that the crows had to stay within as they flew. Each crow still had a brain telling it what to do, but there were physical limits imposed to guide them.”



Smoke emanating from the Balrog was also produced using sprites, with film footage of practical smoke mapped frame by frame onto moving particles. Accumulated fire and smoke elements were layered over a computer animated Balrog model, which incorporated characteristics of recognizable animals to ground the fantastic creature in reality. In the finished composites, the volume of fire and smoke effects obscured much of the monster’s underlying form and movement.

Massive also generated clusters of orc laborers seen preparing for war as the crows return to Isengard—a shot that utilized multiple fourteenth-scale miniatures. “The camera tilts down as the crows dive down into the cavern,” explained Alex Funke, “then we hook up to three fourteenth-scale sets that we fly through on the way to where Saruman is standing on this little observation platform. We did that by moving as far as we could on one set, doing a matted hook-up, then matching that speed and going into the next set, just to get the entire distance.”

The Massive agents created for the orcs in the Isengard scenes were simpler versions of those featured in the prologue battle. “They had very small brains that enabled them to locomote a little bit so they could get around and not just be standing in one place,” Stephen Regelous said. “They could also do some simple cyclic moves, such as bashing away on rocks or climbing a ladder. But even though they were more simple, individually, we had to build a huge amount of brains for those guys because of the variety in their actions. We had the bucket-carrying guy, the chipping-away-at-the-wall guy, the climbing-the-ladder guy, the walking-around-with-a-stick-across-his-shoulders guy. We had these little libraries of motion for the orcs in Isengard so we could sprinkle them around and put guys who were specific to what they were doing in the right places.”

In later shots of Isengard, Saruman is seen creating an army of orc and goblin hybrids called the Uruk-hai, introduced with the ‘birth’ of their chief, Lurtz (Lawrence Makoare), from a bed of mud. As

the Uruk-hai leader, Lurtz was made up in silicone prosthetics for his birth scene and other closeups. For later fight scenes, however, in which he would be performing strenuous actions and would be seen only fleetingly, the character was made up in more durable— but slightly less convincing — foam latex appliances.

“Silicone looks better,” admitted Gino Acevedo, “but it is high maintenance in that it’s very hard to get good blending edges. To blend the silicone around the eyes, for example, we had to apply overlapping pieces of gelatin. We had a great tip that we learned from Howard Berger at KNB, which was to use heated witch hazel to blend the gelatin. The witch hazel seems to attack the gelatin, and it melts right into the skin, creating a great blend.” The gelatin blend pieces presented their own problems, however, as the material tended to melt once an actor became overheated. “We occasionally had to go in and fix the gelatin pieces, and we didn’t want to deal with that in the more action-oriented scenes, where actors were going to be hot and sweating all the time. So we went with the foam latex in those scenes, and it worked fine.”

Rhythm & Hues, in Los Angeles, composited nine Isengard shots, including two featuring Lurtz. “The foregrounds were bluescreen elements of Lurtz,” related R&H 2D supervisor Sean McPherson, “then we had miniature motion control backgrounds for the caverns, which were shot in six or seven different passes— beauty, highlight, smoke, et cetera. Cesar Romero did those shots on the Inferno.”

While the Lurtz bluescreen composites were fairly straightforward, a wide pullback of the cavern, seen just prior to Lurtz’s emergence from the muck, featured successive layers of bluescreen elements composited with a miniature cavern. “That was the trickiest shot we worked on,” McPherson said. “You see Saruman up on a bridge on screen right, and little groups of orcs working through the mud in the foreground. As the camera pulls back, more and more foreground orcs recede into the distance.”

Joe Brattesani executed the shot in Inferno, taking the base layer from the background cavern miniature and stacking in successive layers of foreground elements. “Weta had done one big move on this cavern miniature,” McPherson said, “shot motion control eight times to get the different lighting passes— all of which lined up fine. We were able to pull keys at different portions of each pass and put them together to create one whole half of the cavern receding into the distance, and that became our background level. Then, on top of that, we had to put in all these foreground layers that stacked up toward camera.”

Foreground elements consisted of Saruman and various orc performers executing actions in front of a bluescreen. “Once we got the basic blocking with all of our large foreground layers,” McPherson elaborated, “we populated the cavern with all these little bluescreen orcs, which were tracked to different areas of the cavern. There ended up being about 25 orcs in the shot. They’d given us ten, and we had to clone them and put them in different positions to fill the cavern.”

Other Isengard shots assembled by Rhythm & Hues were two in which Saruman is in the foreground, watching as his orcs pull down the trees of the surrounding forest, with the Orthanc tower in the background. Paintings provided by the production gave a clue as to how dark the sky and mountains should be, and how highlights should reflect off the tower.

Still en route to Mordor, the fellowship journeys through a narrow mountain pass made more perilous by a snowstorm and an avalanche— both summoned by Saruman’s dark magic, but realized by the miniature effects crew. “The avalanche was done with a mixture of table salts and bicarbonate of soda and other strange ingredients,” Alex Funke stated. “We wanted to get a snow that would be clumpy, but would fall as powder, and then clump again when it hit something— just as wet snow really does. A whole series of dump tanks was rigged to drop the stuff on a miniature as the camera shot it at 120 frames a second.

“Peter was very specific about the sequence of events— how much snow fell, where it fell, what density it was. The snow was preloaded on a tray with hydraulic rams to push it; but it was all sequenced so that, first, a bit of snow would be pushed out; then some rocks would be pushed out; then a big mass of snow; and then some debris falling after. All these things had to be fired so that they came down in the right order.” The miniature photography was intercut with live-action elements of the actors on location at a real snowy mountain pass and within a studio set made up of cast rock faces sprayed with melted wax to create an icy look.

The fellowship is forced to turn back and reroute through the Mines of Moria, where dwarf miners and their leader, Balin, have died in battle with a goblin army. Near the gated entrance to the mines, realized as a full-scale set, the companions are attacked by the Watcher, a giant, squid-like creature that emerges from an adjacent pond.

The Watcher was modeled and animated in Maya, based on a Weta Workshop design. “We didn’t want the Watcher to just be a tentacled mess, out of control,” Richard Taylor stated. “It had to feel as if it was going specifically for Frodo because it was pursuing the ring. We analyzed that creature at great length— things like the structure of its tentacles. We designed it to have two fingers and an opposed thumb at the end of its tentacles, with squid-like suckers on the inside. Its mouth was like a sphincter, and it had six huge wing-like structures down its back, which are closed when it’s below water, but flare into massive wings when it’s above water. We analyzed how and where it would intake air, how it would shield its eyes. We put a lot of time into developing its eyes, to give it a look of an old man’s intelligence, with puffy, soft, weepy eye sacs. We deemed it necessary to put in all that time and research, to create a creature that was worthy of the project.”

The template for the Watcher— and all of the show’s computer generated characters— was a detailed clay maquette sculpted by Workshop artists. In a traditional approach, the digital modelers would have modeled the creature by eye, referencing the sculpture, or loaded photographs of the maquette into the computer, resulting in a rough CG approximation of the detailed maquette. But at the start of *The Lord of the Rings*, Weta became involved with Applied Research Associates, a local



Distraught over the loss of Gandalf, who, with the Balrog, has fallen into the fiery pit below the collapsed Khazad-dûm bridge, the fellowship finds refuge in the treetop city of Lothlórien, the forest kingdom of the elves. A limited full-size set comprised of massive tree bases was used for live-action shots of the characters at the ground-level of the city, while treetop views relied on a fourteenth-scale miniature. For a shot of the fellowship climbing a spiral staircase, digital doubles were composited within the Lothlórien miniature.

company that had developed a groundbreaking 3D scanner, later picked up in the United States by Polhemus and marketed as FastSCAN. That 3D scanner became invaluable in capturing data off the scale creature maquettes. “Its strength was that it was not only incredibly accurate,” said Matt Aitken, “it was free-form. The digitizing wand— attached to a host computer via cable— had a laser beam emitter, two offset video cameras and a magnetic tracking system. It was free to rotate at any angle in relation to the object being scanned, so there weren’t areas in shadow to the scanner. The wand could get into every nook and cranny.”

“The scanner was extremely successful in capturing minute detail,” Taylor elaborated. “To facilitate this high-end scanning, we created very large-scale scannable maquettes for some of the creatures — five to six feet tall, in some cases— with no metal in them, because that negatively affected the scanning process. As the scan progressed, we could literally see the creature growing in real time in the computer. It was fantastic. One of the problems with visual effects is that it is too easy to change things, and to screw with the designs. With this technology, we could very tightly control the art direction of the creatures— what we designed and built was re-created in the computer very accurately.”

In the course of several passes, the scanning laser would be moved over every surface of the maquette. Software attendant to the scanner would then stitch those passes together, creating a single surface with no overlapping data due to its ability to recognize when the laser was passing over a point already scanned. What resulted from the scan was a highly detailed, single polygonal mesh model. “We still felt that it was valuable to convert that into a NURBS model,” Matt Aitken stated, “because NURBS models are better for organic subjects, and they have a coherency that is useful for the next step, which is extracting the displacement map. So we used Power Animator to convert the single shell from the scan to a NURBS model.”

A ‘lightweight’ version of the model— a digital puppet— was delivered to the animation department. The animation for the Watcher and all of the CG creatures was slightly stylized and harked back to stop-motion creatures of movies past— in shot design, if not in execution. “Both Randy Cook and I come from the stop-motion world,” Adam Valdez explained. “I apprenticed under Phil Tippett for eight years, and learned just about everything I know from him. So that was a factor in the classic style of the creature shots. But, more importantly, it was Peter’s preference. He is a big fan of classic animation, so some element of homage to the work of Ray Harryhausen was incorporated into the creature designs and sequences. It’s not so much that we went for a stop-motion look in



the animation; it was more that Peter's and Randy's staging of scenes, with big reveals and other theatrical elements, was reminiscent of stop-motion sequences of the past."

A real animation department did not even exist at Weta Digital at the onset of the *Lord of the Rings* project; and so, one of Valdez's and Cook's challenges upon their arrival was simply setting up the unit. "We had to come up with conventions for how we would build our puppets," noted Valdez, "how we would build skeletons underlying the puppets. We did a lot of motion studies to sort out technical issues as well as artistic and creative issues. So we had our hands full when we first got here, just trying to determine how we were going to do things. Some studios have been doing animation for years and over many shows, and so they have developed their technical approach—but we had to figure all of that out pretty fast."

The frenetic nature of the Watcher sequence made it a difficult animation job. “It was a very quick action-based sequence that needed to communicate a hell of a lot in a very short period of time,” Valdez explained. “It was fast, and the camera work was all over the place— but you still had to be able to read what was going on plainly amidst twelve tentacles and splashing water and whizzing arrows. So it was one of those scenes where, as an animator, you’re fighting to integrate some sort of character and style into it, while dealing with all the technical difficulties. Just animating all the tentacles to keep them fluid and powerful and looking as if they were all coming from a single mind was really tough.”

Completed animation was passed to the Weta Digital creatures team, where the lightweight model was fleshed out with skin, bone and muscle. Software development supervisor Richard Addison-Wood wrote a proprietary muscle system plug-in for Maya, which could do shape calculations to figure out what the muscle shape should be when the CG model’s skeleton was manipulated. “To create muscle,” stated creature supervisor Eric Saindon, “we would just select points on a bone of the model. If I selected a point on a bone and then a second point somewhere else, I could type a command that would create a muscle there for us. Then we could adjust those to determine how big the muscle should be.”

“Compared to many others in use, our system was a lot closer to reality,” Addison-Wood asserted, “because, just like on a real body, muscle movement was driven by skeletal motion, and the movement of the skin was determined by what the muscles were doing. Recently, a lot of effects houses have begun developing their own muscle and skin systems, working on this concept of creating convincing behavior by modeling what is happening on the inside, not just the outside. This layered approach is the wave of the future.”

Displacement maps— added at render time— gave the CG creature models their surface detailing. Typi-



Based on an illustration by conceptual designer Alan Lee, the Lothlórien miniature featured ornate staircases winding around massive tree trunks and more than a hundred wax-carved elven dwellings in eight towering treetops, sculpted and cast out of urethane and dressed with thousands of sprays of artificial leaves, all hand-applied. The completed miniature measured sixty by eighty feet and filled production’s largest shooting stage. / The setups were shot in heavy smoke to create a magical, misty look. A sense of scale was achieved by filming groups of miniature trees motion control, one layer at a

cally, displacement maps are painted in 2D and applied directly to the surface of the model. Weta Digital, however, created its displacement maps

time, allowing them to be composited with a multiplane effect.

using the highly detailed data derived from the maquette scans. “We were able to take that scan and create a simpler version of the model that could be animated,” noted Matt Aitken, “but, at the same time, were able to preserve all the gorgeous detail from the scan by converting that into a displacement map through a Maya plug-in that we developed in-house, inspired by a Siggraph paper by Venkat Krishnamurthy and Marc Levoy. All that data was put to one side until the creature was animated, skinned and run through the muscle model process. Then, at render time, the TD picked up that displacement data again and applied it to the creature model; and, instantly, all the detail that was in the original clay maquette was re-created on the surface.”

In addition to modeling, animating and rendering CG creatures, Weta Digital produced digital doubles for all of the leading actors, which were employed in the Watcher sequence and throughout the film. The model team started by scanning a generic human body— that of a trainer in a local gym. “He was a good starting point,” commented Aitken. “We didn’t use our hand scanner on him, because we didn’t want to have to cast him. We wanted to just grab him as a snapshot. So we sent him to Los Angeles, and he was scanned with a Cyberware full-body scanner. We got that data back, and went through our usual process of converting it to a NURBS model. Then, once we had our generic human NURBS model, we just stretched it and changed the basic shape, depending on the proportions of the actor we were creating a digital double for.”

The 3D scanning tool that was used on the creature maquettes was instrumental in creating the faces of the digital clones, as it allowed the faces of the actors to be scanned quickly and easily as they came off the set, still wearing the appropriate prosthetics. “I’d get the actors to pull a whole range of facial expressions— worried, relaxed, angry— and I’d scan all of those expressions,” Aitken said. “They had to stand perfectly still during the process, and it worked best if they held their breath for the entire ten seconds it took to capture an expression. It was quick and dirty — - not nearly as meticulous a process as when we scanned the maquettes— but it gave us a good likeness and enough detail to work off of. We then used those scans as a basis for building the different faces for these digital doubles.”

Unlike the creatures, some of which would be seen in extreme closeup, the digital doubles were designed to be seen only in quick, action-oriented cuts; so the level of detail and accuracy did not have to be as high. However, the digital doubles presented a problem that most of the creatures did not— the need for simulating clothing and hair. For the dynamic cloth simulations, the model team often used Maya Cloth to drive NURBS versions of the clothing, which had finer detail sculpted into it. “For Gandalf’s robe, for example,” noted Aitken, “we didn’t want all of the folds of the cloth to be represented in the Maya cloth model, because it would have been too heavy a model to add dynamics to. So we had a lighter version of the cloth to work with, and then we had more of the fine detail sculpted into the model that was driven.” The hair was an in-house simulation developed by Addison-Wood’s team. “You model key hairs, or guide curves; and then at render time, a lot of different curves are interpolated between those guides. Quite a lot of sculptural detail had to go into capturing the look of the hair— but it paid off.”

In the Watcher scene, Frodo is entwined in a tentacle of the creature, then rescued by Aragorn and Boromir, who splash into the fetid, swampy waters to slash at the creature with their swords. *George Ruge* staged live-action elements of the fight with the Watcher, helped along by his crew members who stood waist-deep in the water and held up eye-line stick references the sword-swinging actors could aim at. Combining those live-action elements with the CG Watcher and the digital doubles was tricky, both because of the splashing water and the human/hobbit scale issue. “It was the typical nightmare of integrating a CG creature with live-action water,” commented 3D sequence lead *Greg Butler*, “and integrating a CG creature with the actions of live performers. When it was just the humans interacting with the creature, it wasn’t too much of a problem; but it was a huge problem when there were hobbits in the shots. Instead of scaling up the Watcher in those shots—which would’ve been a challenge for our pipeline— we shrunk the entire digital world by twenty-five percent.”

“The interaction between the creature and the water was the most challenging part,” elaborated *John Nugent*, “and that was achieved with a mix of CG water elements and practical water elements. Our miniature photography crew was quite cooperative in providing elements such as leading-edge water interactions for when the Watcher’s tentacles came out of the water, pushing and splashing the water forward and dragging a wake behind them. There were also specific water dripping and spraying elements. We had quite a library of water elements that the compositors, under 2D lead *Paul Kirwan*, could incorporate into the comps with the CG creature.”

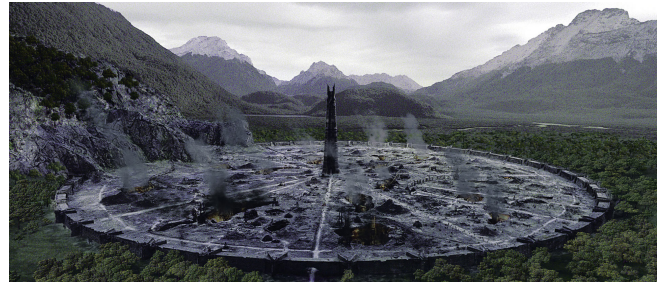
The fellowship survives the Watcher and enters the Mines of Moria, the abandoned realm of the dwarves. Digital color grading was a pivotal element of the nearly twenty-minute-long Moria sequence, as Jackson had decided that his lead characters should have a sickly pallor throughout. “I wanted to create the impression that as they go into the mines, the life is drained out of them,” stated Jackson. “So they would all have a gray, lifeless look to their flesh. The grading tool allowed us to do that.”

Grant Major designed full-size sets for the mines that revealed a progression of color and texture from the entrance to the deep interior of the stone world. Major also designed the sets to clearly illustrate the dwarf culture. “Whereas elves work with wood and nature,” observed Major, “dwarves live under mountains and hack out spaces with stone tools. Even their writing is chipped out of stone, like Egyptian hieroglyphics. Their style is also more angular, art deco in its bluntest form; but their culture is glorious in its own way.”

While the first entrance into the mines and other medium-to-closeup sections for the live-action were full-size sets, wide views within the Mines of Moria were miniatures. An exception was the vast, abandoned dwarf city of Dwarrowdelf, buried inside the mountain. Made up of towering, rock-carved columns—modeled by Matt Aitken’s team—Dwarrowdelf was an entirely digital environment, one of the few featured in the film. “There aren’t a lot of reasons, in my opinion, to use a digital environment when a miniature can do the same thing,” asserted Jackson. “With a miniature, you can control the lighting, there’s more flexibility, and I just think it looks more realistic. But we used a digital environment in the Dwarrowdelf sequence because we had to show these endless rows of columns going off into infinity.”

Space-spanning camera moves envisioned by Jackson also mandated a CG, rather than miniature, environment. “We had these huge camera moves from the ceiling of Dwarrowdelf,” said Ellen Somers, “watching the orcs encroaching on the fellowship, and the fellowship running great distances in the chamber to escape. There was no way we could have done those camera moves on a real set and tracked all the elements in—not in that huge a space and at those distances.”

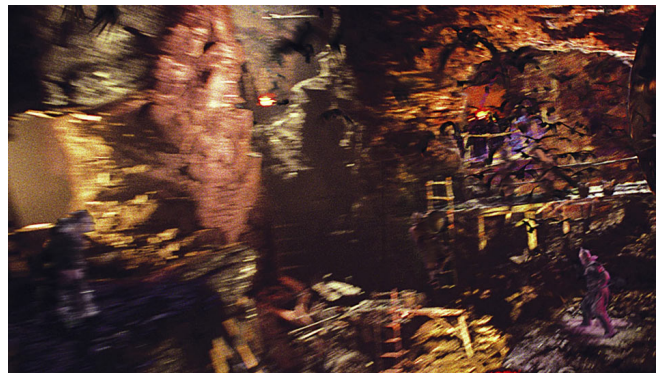
“The challenge of Dwarrowdelf was its vast scale,” affirmed visual effects art director Jeremy Bennett. “The ceiling was supposed to be ninety feet high, with pillars fifteen feet across—a forest of stone. Peter really wanted the audience to get a sense of how big this place was.” Simple cloning of the columns to get them repeating into the background was not sufficient. “We ended up hand-tailoring almost every one of those columns,” Jim Rygiel commented. “If we had just done a duplication thing, you would have picked up on that right away. So we had to randomize each one slightly to give the whole thing a chiseled look.” A lighting cheat helped to emphasize the intended scale. While Alan Lee’s original artwork dictated that the main light source would come from Gandalf’s staff, the CG lighting crew created a rim light—for which there was no justification—to reveal the immense size of the dwarf chamber and its rows of receding columns.



The fortress city of Isengard has been ravaged by the wizard Saruman, an old friend and mentor of Gandalf's who has joined the forces seeking to restore Sauron to power. Several miniatures were built to represent Isengard. The largest, an exterior set some sixty feet in diameter, surrounded by a poured concrete perimeter wall detailed with prefabricated urethane panels, was surfaced overall with a layer of sprayed rigid polyurethane into which a scattering of uprooted tree trunks and industrial equipment was implanted. A forest of miniature trees was erected outside the fortress perimeter, and a digital cyclorama provided background mountains and skies.



A flock of digital crows leads the way in an Isengard flyover shot that swoops down into and through a labyrinth of caverns beneath the city. Clusters of orc laborers— computer generated and animated via Massive— were composited into the fourteenth-scale miniature settings. The extreme length of the shot, and the supposed distance traveled by the camera, required the digital connection of separately-shot motion control passes through a succession of miniature settings. The shot concludes on Saruman (Christopher Lee)— a bluescreen element composited into the miniature photography.



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Making its way through Dwarrowdelf, the fellowship — represented by digital doubles in some of the shots, particularly wide views— defends itself against thousands of Moria orcs. Actors or their stunt doubles were motion captured to create the CG performances, and that basic mocap action was then enhanced through either animation or the Massive simulation. “We didn’t have motion capture for all of the fellowship’s actions,” said Stephen Regelous, “particularly in the Mines of Moria, and it would have been a lot of work for the animators to generate a whole sequence of motion for all nine of those characters. We found that it was easier to generate the motion from a Massive version of the character. We could just import the models and give them very simple brains that enabled them to look around a bit and not bump into things. We’d either apply the brains to the detailed CG doubles that had been created, or to a slightly cut-down version for shots where they were going to be quite small in frame.” Most of the orcs in the scene were also digital. “Some of them got very close to camera, much closer than we’d planned on. That was really pushing the bounds of what we could do with Massive.”

For a few of the live-action Moria orcs seen in closeup, Rhythm & Hues created digital eye enlargements— the rationale being that because the creatures lived in continual darkness within the mines, their eyes would have grown larger over time. “It was something that Peter always wanted in the show,” noted Jim Rygiel, “a kind of crazed, open-eyed look to the orcs— but it was difficult to get with prosthetics. The makeup guys did them up as much as they could, knowing that we were going to go back and expand the look later, digitally. But it turned into more than just taking the eyeball and morphing it open. When the artist did that, everything just became blurry; so they literally had to go in and reconstruct 3D eyes. It was one of those things that started out as a simple effect, but became more and more complicated.”

Fleeing the orcs, the fellowship arrives at the tomb of Balin, realized as a live-action set. There, a monstrous cave troll smashes through a door and into the chamber. The computer generated beast



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evolved out of a lengthy design process. “The difficulty was coming up with a troll that didn’t look too comical or fantastical,” Christian Rivers explained. “We didn’t want something with pointy ears and a big nose and fangs. We wanted the troll to look like a creature that actually could exist.” A Workshop clay maquette, standing more than five feet tall, was scanned with the FastSCAN wand, providing the basis for the digital model.

The ensuing battle between the live actors and the computer generated cave troll was first worked out for purposes of previz through a virtual reality system that enabled Jackson and his camera to get right into the middle of the action. “It occurred to me that among the things you could do with motion capture was capture camera moves, not just performer moves,” Randy Cook recalled, “So I asked the motion capture guys to set up a system where we could actually handhold a camera and capture that camera’s motion in a small live set and in a computer set.” A digital previz set was built, based on blueprints for the live-action tomb set. “The idea was to attach the virtual camera to a node that you could hold in your hand, so you could actually walk around the set holding this camera, and you would see the set through virtual reality goggles. John Shiels, who set up the visual effects architecture for the show at Weta Dig-ital, had had the same idea for several years. I went to him with great excitement, and said, ‘We’re going to do a virtual camera!’— and he said, ‘Yeah, that’s been the plan for about three years now.’ John had wanted to do it, but the idea had lain a little dormant.”

The first step was to motion capture the troll fight on a rudimentary set built on the motion capture stage. “We did it as a theatrical piece,” explained Cook, “with no particular mind, as yet, to camera angles. It was just this little theatrical action where a guy would toss an ax at the back of the troll; the troll would chase him and try to hit him with a hammer; the guy would dive between the troll’s legs and jump up on a table; the troll would turn around and smash the table just as the guy jumped off, et cetera. We captured a performer in a suit playing the troll and then the same performer playing the human character at two separate times, and at two different scales, so the guy in the suit would look like he was twelve feet tall in the final digital image.

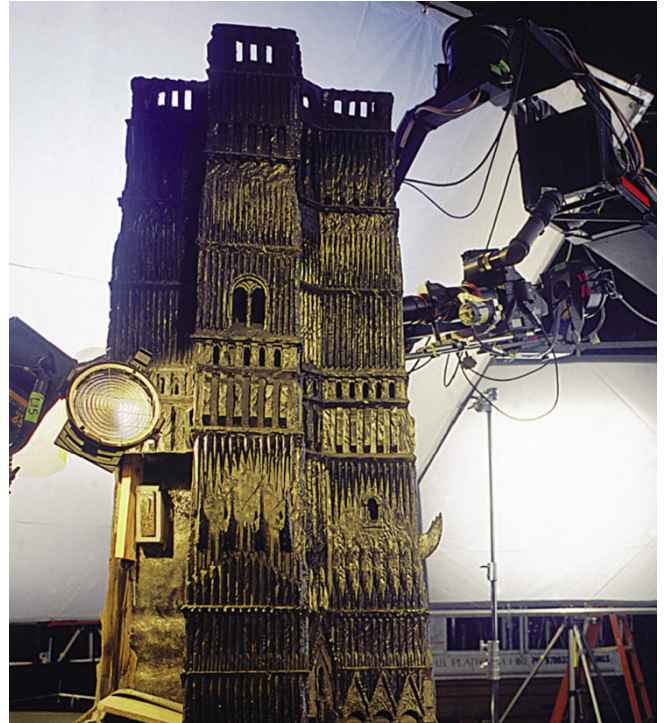
“I directed the actor as the troll to react on counts, like dance choreography, and we had marks that he would hit on specific numerical counts. We blocked it out so that at ‘12,’ he would take an ax hit in the back; at ‘15,’ he would turn; at ‘20,’ he would slam the hammer down, et cetera. Then, when he was playing the character being chased by the troll, he again reacted to the counts; but there was a much bigger volume captured because he was now human-sized rather than troll-sized. The troll was twice human scale, so the space he was in was only half as big as it was when it was scaled for the human character.”

From the motion-captured performance, the previz crew animated the troll and created a rough, blocked out version of the scene. The previz troll animation was aided by Character Mapper, a motion capture innovation— developed by Giant Studios, which also provided Weta with its motion capture hardware, software and cameras— for scaling human motion to disproportionate creatures. “Character Mapper lets you set up exactly how motion transfers, or ‘maps,’ from a human performer to whatever character you want,” motion capture supervisor Francois Laroche explained. “If you were to map human motion directly to the troll, his hip movements would be effectively amplified by the creature’s disproportionately large hip radius, causing his feet to swing around. But

Character Mapper allowed for the creation of a map specific to the troll's skeleton that de-emphasized hip movement, while focusing on stable foot placement."

The motion captured performance data was fed into the computer and applied to the 3D digital set. "So now we had all of that in the 3D world—the motion capture data of those characters interacting within the digital tomb set," noted Cook. The next step was to actually motion capture the camera as it moved through that 3D space populated by the troll and human characters. "We took the handheld camera and hooked it up to VR goggles, which were being fed the information that we'd captured before—the guy and the troll in the set. At the same time, the VR goggles were also being fed the information derived from the camera box we were holding. So we were able to run around like newsreel cameramen, looking up at this big damn troll chasing this guy around. You would be scaled to the size of the set, so that when you put on the goggles, you felt as if you were in the actual set with those characters. If there is a twelve-foot troll standing in front of you, you have to look up at him; and if you look over to the other guy, he is your size. You see everything as if you were actually in the shot."

After a demonstration of the technique, Peter Jackson donned the VR goggles and walked about the digital tomb himself, executing the style of camera movement he wanted to see in the final sequence. "I wore a kind of headset and held a piece of wood that represented the camera," Jackson recalled. "Although it was just a wooden stick with some wires on it, I was able to nominate the lens that I wanted to put on my circle camera. So I'd say, 'Put a 20mm lens on it.' And then I'd just be in this empty warehouse with my headset on, and I'd start walking with my camera. What I'd see in the goggles was a point of view from inside the set. I could spin around, aiming my piece of wood, and I'd get a view of exactly what the set would look like if it was photographed from the position I was standing in. Then the blocked-out action—which in this instance was the fight between the animated cave troll and a few animated human beings—would get played in the set. So I'd be standing there, seeing what would be seen through the camera lens. I'd get a glimpse of the troll and I'd swing the camera toward him, then tilt up to his face; then I'd pan to the right and see someone coming to attack the troll, then pan back to the troll to see his reaction. It was all handheld—I'd run out of the way when the cave troll was coming towards me, keeping the shot in frame. It had this combat photography feeling, as a result. I didn't



At the center of Isengard is the Orthanc tower where Saruman plots his dark deeds. The tower, constructed in miniature by the Weta Workshop, was based on a design extrapolated from a decade-old book illustration by Alan Lee. To create site-specific reflections on the surface of the structure—supposedly hewn from obsidian—the miniature was surrounded by a collage of color xeroxes of stills shot on the live-action location, resulting in a physical cyclorama that reflected the appropriate forest shade of green onto the tower's lower sections. An illuminated white panel draped above suggested sky reflections on the upper portions of the tower.

know what the cave troll was going to do next, but I was standing right by him with a camera to film him.”

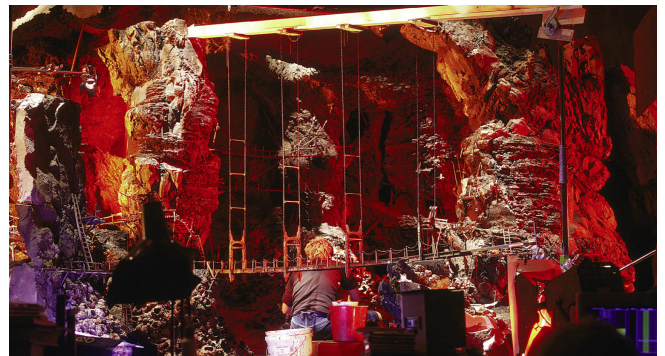
Working off of Jackson’s overall brief, Randy Cook then donned the goggles and shot multiple angles of the fight with the virtual camera. “The advantage,” stated Cook, “was that we had our digital troll there and our digital hobbits, and things would just occur to me as I walked the set— just as they always do on your first day on a real set. You always come up with things that are different than what you originally imagined. For instance, it was immediately evident that this wonderful set had a mezzanine level that wasn’t really being used. So we decided to bring the fight up to the mezzanine level at some point, chest-height with the troll. We did a whole series of beats on the mezzanine, including things that were cut but will show up on the DVD— Legolas and Gimli getting caught in a little alcove and Legolas throwing a big spear at the troll.”

Another idea that came up during previz was that of putting the cave troll in chains. “Part of the job of blocking out the scene was to come up with acting business,” said Cook. “It seemed logical that if a bunch of goblins broke down the door and had a big troll along with them, the big guy would look like he was the boss. So how do we make it clear that the troll is actually the goblins’ flunky? I thought, ‘Have them drag him in on a leash— that’ll make it clear.’ And we thought we might as well make the leash something that could be used as a flail, so we made it a chain. So now he had a hammer and chain, which made for a more interesting fight.”

After Jackson had taken the VR material into the Avid and cut together the previz version of the fight, camera operators studied the assembled scene in preparation for shooting its live-action elements.

“Once the action was locked,” stated Jim Rygiel, “the camera operators watched the footage over and over again, and then just copied it on the set. It was a low-tech way of doing it. We could have gone to a very time-consuming, high-tech way of doing it, taking all the handheld camera data and applying that to a motion control system on the set as a means of replicating those moves. But the low-tech approach allowed for more flexibility. We could change things on the day of shooting, if we wanted to.”

Changes were implemented on the spot, regularly. “We shot the actors on the set with that choreography in mind,” Cook commented, “but we weren’t enslaved to it.” After live-action elements were captured, animators began executing key-frame animation for the troll. “Peter came back and worked very closely with me and the animators to get the scene to the intensity level that he wanted. The animators approached the sequence like actors, and we were always mindful of conveying what the troll was thinking, on top of what his body was doing. We went so far as to write out interior dialogue for the troll, and then have his eyes and facial expressions convey that interior dialogue as much as possible. It was something I’d never done before, because I’ve mostly



Motion control technicians and on-set modelmakers prepare for a shot inside the caverns beneath Isengard. The miniature set was dressed with hundreds of pieces of crude scaffolding and articulated industrial equipment, driven by stepper motors. In final shots, orc laborers—created in Massive and implanted with limited, but specific behaviors keyed to their individual work tasks—were positioned and activated to create the impression that the machinery was being operated manually.

worked by myself. As a lone wolf, I could just work out a character's interior dialogue in my head, without writing it down. But this time, I was an orchestra conductor, rather than a soloist, so I had to come up with a way to get a similar result. I lied to the animators, actually, and told them that writing out interior dialogue and animating to that was an old trick— which it wasn't. It was just something that occurred to me on this show."

Creature TD Bay Raitt spearheaded the facial animation setup for all the digital characters, including the troll. "Bay developed a fairly elaborate, accurate and versatile system of facial animation," Cook stated. "In fact, it was so versatile, it allowed the face to do much more than it needed to for the troll, so we had to exercise restraint. The troll didn't need to be too expressive; but we still wanted him to convey more emotions than just anger and aggression, to create some sympathy for the character."



Whether with hairy hobbit feet, pointy elf ears or enlarged wizard noses, nearly all of the principal actors were subjected to some form of prosthetic makeup. Gino Acevedo applies a gelatin nose appliance to Christopher Lee.

Throughout, the animators attempted to bring a sense of pathos to the cave troll sequence, a quality present in many of the classic Ray Harryhausen creature scenes. “The cave troll sequence is very much like a Ray Harryhausen sequence,” Cook admitted, “in that a monster shows up, fights with people, and is killed. But Harryhausen always tried to bring out the pathos of his creatures, and we did the same thing here. We wanted to make the fellowship’s victory somewhat ambiguous. They have to kill the cave troll, or else it’s going to kill them— but they don’t feel particularly good about it afterwards.”

Fellowship digital doubles were featured heavily in the cave troll fight. A CG Legolas, for example, is seen ascending the troll’s taut chain, then landing on the creature’s back, at which point the shot cuts to a closeup of Orlando Bloom. Subsequent wide shots of Legolas riding the troll as if on a bucking bronco were accomplished through a combination of live-action and CG. “We put CG legs on the real Legolas,” Cook explained, “just so we could really lock him onto the troll. We also had a digital Legolas grab onto the troll as he bucked around like a mechanical bull, and then we had him jump off.”

Digital characters performed many of the dangerous stunts in the sequence, such as Aragorn being swatted through the air and the hobbits leaping onto the back of the troll. “We had them not only for impossible-to-achieve moments like those,” Cook noted, “but also for difficult-to-achieve moments. For example, there were times when we couldn’t get either Elijah Wood or his stand-in, Kiran Shah, to a particular set, because they were both working on other sets. Because of that, we used a digital double for a shot of Frodo scurrying out of frame, after Aragorn has leapt in next to him. We also needed a quick shot of Frodo’s foot being grabbed by the troll, but we didn’t have the real Frodo in that particular corner. So we used the very accurate, convincing Elijah puppet for that. All of these characters were built to a much higher degree of fidelity than they are given a chance to show in movie one. They were very good models, with a library of expressions, eyes that were just the right color— the whole thing.”

Having dispatched the troll, but now pursued by an army of orcs, the fellowship approaches a crumbling M.C. Escher-style stone stairway that appears to descend into infinity, and the bridge of Khazad-dûm, which extends over a fiery chasm. Among the most ambitious in the film, the Khazad-dûm sequence was the first to be previsualized; and in the course of the process, an initial 100 shots was refined to forty-some. Miniatures led the way as, before previz started, Weta Workshop had constructed a fourteenth-scale model— a massive set that stood 21 feet tall, 66 feet long and 45 feet wide. “The stairs of Khazad-dûm was the most comprehensive miniature we built for the Mines of Moria,” Richard Taylor said. “It took about four months to complete; and it required a lot of



In his thirst for power, Saruman breeds orc and goblin hybrids to create super-warriors called Uruk-hai. For closeups of the Uruk-hai chief, Lurtz (Lawrence Makoare), Workshop team members created a full-body makeup featuring multiple silicone appliances. Around the eyes, the silicone was overlapped with pieces of gelatin to create a superior blend. For action scenes, Lurtz and other hero Uruk-hai wore appliances made of more durable foam latex.

planning to figure out how to make all the components interlock and fit into our studio, then go out the door and reassemble easily. The set consisted of the door the characters burst through, the maze of stairs, the little bridge across to the great hall, the great hall itself, the bridge across Khazad-dûm, and then the stairs going out.

“It was an all-inclusive miniature with huge architectural elements soaring up the walls, which were seven meters tall. We built it mainly out of industrial tin foil, backspraying that, and then skinning it with urethane rock castings, carving elaborate architectural components into that. The camera, at any one time, was within a half inch of the surface, so it had to be quite detailed. It was one colossal model, large enough that a person could walk around in it freely, and camera equipment fit in it easily.”

For the purposes of previz, Randy Cook’s team took measurements off that model and reproduced it in 3D Studio Max. “Our previz was a computer puppetoon with very basic figures and animation,” said Cook, “and with rudimentary paint jobs on them just to distinguish one character from another. It looked a bit like a BBC production of *The Tempest* as played by wooden Christmas tree ornaments! But we had to choreograph them through this very elaborate scene and come up with interesting gags, beats and action. Then Peter would come in and pick what he liked and add other things. Ultimately, the previz was followed very closely in the final sequence.”

Final shots consisted of Alex Funke’s photography of the Khazad-dûm miniature, a project that spanned a full year. “The miniature held up well through all that time,” noted Taylor. “The only thing that went wrong was that we’d have birds and insects flying through shots from time to time. In rushes one day we saw a lizard. No one had seen it during the motion control shoot because it had been done so slowly; but, sure enough, in rushes we saw this colossal lizard come walking up the stairs and through the shot. It was fantastic, even though it ruined the day’s filming.”

While the miniature provided the immediate environment in the final shots, 3D matte paintings extended the set, creating the illusion of an endlessly winding staircase. Also extended was the fiery chasm beneath the bridge. The roiling lava effect had been simulated on the miniature through bottom-lighting; but because of limited stage height, the miniature chasm had only extended down



In keeping with Tolkien’s vision, three distinct races of orcs were created for the film, including the warrior orcs of Sauron’s army, the smaller cave-dwelling Moria orcs, or goblins, and the hulking Uruk-hai hybrids. Within these races, each featured individual had distinguishing characteristics. For hero orcs, Weta Workshop designed and produced full facial appliances, body prosthetics, and hands and feet, all made of foam latex. Hero makeups took four to five hours to apply. Background orcs were fitted with foam latex slip-on masks and body suits.

about four feet— not deep enough for shots looking straight into it. For those shots, a digital extension was required.

“We had to do matte painting extensions for these areas going into the abyss, lit by roaring fire coming out of the rocks,” explained matte painting lead Max Dennison. “It was a saturated red glow, so we had to composite in fire stage elements, but be careful to match the key lighting of the miniatures. We took a still from the set and redesigned the lighting back onto the matte painting patches. We would take a certain frame from the clip of the miniatures, make a matte extraction, apply that patch back onto the 3D environment, and render it through our environments department. Our 3D department had all the motion control camera data to match what they shot on the miniature set, and that was imported, along with digital doubles.”

The signature beauty shot within the Khazad-dûm sequence is a huge, arcing 516-frame move revealing the Grand Canyon-scaled chasm, with the fellowship running across a narrow rock bridge. In addition to the miniature, the shot featured the CG set to extend the chasm to infinite depths, bluescreen characters mixed in with digital doubles, and at the tail end, a towering beast of fire and smoke. The expansive shot was complicated by the fact that the camera move on the bluescreen actors did not match the miniature camera work throughout. “The perspective did not match at all,” Gray Horsfield said, “so we had to change the miniature element at the beginning to a direction that would line up with the bluescreen foreground guys. Of course, that meant that we were tiling up and seeing much more of the miniature than was actually shot. So we had to reconstruct the miniature as a digital set that we could move the camera around in any way we wanted.”

That set was derived from the model photography.

“We took the miniature footage and projected it onto a new digital environment,” explained Wayne Stables, “and literally reworked the camera so that it worked for the shot. The geometry was fairly simple. We didn’t have to model detailed rocks or anything, because we were still using the original miniature photography, projected at certain angles. Basically, we texture-mapped this digital environment with the original photography from the miniature.” The setting reverts from CG replication to original miniature photography as the fellowship reaches the far side of the bridge.

The animation of the digital doubles on the Khazad-dûm stairs was derived from motion-captured footage of the actors or their stand-ins running down practical stairs on stage. “We had a huge motion capture stage,” said Jim Rygiel, “and we could capture volumes of up to fifty feet long. Normally, you’re restricted to a ten-foot cube with motion capture; but this was a large expanse of fifty by twenty feet, about twenty feet high. So we built a



Leaving Lothlórien and venturing on toward Mordor, the fellowship journeys by canoe along the River Anduin, eventually approaching a narrowing of the river that leads to Argonath. At that passageway stand the Pillars of the Kings, two towering statues. The monolithic figures and adjacent rock faces were part of a large miniature set, composited with live-action river elements of the characters in their canoes, shot on location.



staircase and motion-captured them running down the stairs— shooting them separately, several different versions of each. They were only running down about fifteen feet of stairs; but in the film they were supposed to be running fifty feet down. So we motion-captured each performer five times, running a little differently each time. Then we would stitch all of those cycles together to get one continuous run of fifty feet.”

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That ‘stitching’ or blending of the motion capture cycles fell to the motion editing team. “That whole shot was heavily dependent on motion editing,” commented Randy Cook, “which is a kind of key-framing. I also went in and hand-animated the characters’ faces. In a couple of the shots in that sequence, the digital doubles are completely hand-animated, because the stairs on the motion capture stage were very precipitous and difficult for an actor to run down very fast. Key-frame animation was the only way to do it.”

Chasing the fellowship onto the bridge is the Balrog, a flaming thirty-foot-tall creature in a cape of black smoke. The design of the Balrog — described in Tolkien’s book as ‘both a shadow and a flame, strong and terrible’— was more difficult to pin down than other creatures in the film, due to its fantastical nature. “The Balrog took the longest to realize,” said Christian Rivers, “because it had so many ethereal attributes. Even Tolkien’s description was hard to translate— a shadow blacker than black, with a mane of fire on a creature that was vaguely a shape. A man shape? We didn’t know.”

A published John Howe illustration became the basis of the creature. “John had done some spectacular Balrog drawings before he ever joined us on this movie,” said Richard Taylor. “Ben Wootten, one of our designers, took those drawings and extrapolated from them, and created a very large maquette that Peter thought was perfect.” The maquette had a head that measured four feet tall, and a separate half body, both of which were scanned as the basis for the computer model.

Recognizing that the Balrog would attain its ethereal look through digital enhancements, Taylor and his Workshop artists strove to design a creature that had a solid, reality-based form. “Its skeletal structure was a mixture of a dog and a bull,” Taylor described, “with wings based on the structure of bat wings. It had the tail of a lizard, and its horns were fashioned to look like actual horn material. It also had teeth and skin— the skin just happened to be congealed, cold lava. By basing it in this physical reality, the audience could believe in this fantastical, bizarre creature.”

It was that physical form alone, translated into a computer model, that Randy Cook’s team dealt with in animating the creature. The addition of smoke and fire effects would be the second stage. “We semi-finaled the animation months before we saw smoke,” recalled Cook, “which made it difficult to know exactly how much to animate. As it turned out, we put more work into the animation than we should have, given how much of the Balrog was covered up with smoke. We thought there was going to be more of a real shape, and more definable locomotion. I even had a grand theatrical notion of the Balrog carrying a tail behind him, sweeping like a train on a costume — but it ended up just smoke.”

As a means of introducing fire and smoke to the 25 Balrog shots, technical director Jim Callahan developed a physics-based fluid dynamics system and volume renderer. “The system I wrote was based on the actual physics that were going on,” Callahan said. “It modeled the actual physics and behavior of fire. That’s different than a program that tries to mimic the way fire looks by using patterns like fractals or noise functions. An off-the-shelf commercial package like Houdini or Maya employs particle systems that use simple rules. Particles don’t really interact with each other— they just follow rules that have been applied to them. My system, in contrast, relies on the interactions between particles, mimicking the physics that happen in reality to produce a look, structure and movement that are natural looking. But in order to do that, you have to have very small-scale interactions; and a huge number of particles are required to make it look seamless and smooth, without seeing the underlying particle nature of it. So the system was designed around the idea of its running on a number of processors, simultaneously. Most of our simulations had thousands of times more particles than you’d find in a commercial package.”

Ultimately, though solidly based in physics, Callahan’s system was deemed too render-intensive to be useful for the Balrog shots. Ironically, the system also produced fire that behaved in too real a fashion. “Since the Balrog was moving around and running,” Jim Rygiel related, “the minute we put this physics-based fire simulation on him, it would blow out— because that’s what real fire would have done. Or it would waft about in a weird way that we didn’t want. We could control some of those things, but the whole effect looked too real. We knew it would be great for other things, but not the Balrog. So we started looking into other possibilities.”

After several failed experiments in puppeteering practical gas jets, the live approach was rejected in favor of a digital one Gray Horsfield had been developing. “I did a test initially, which was just a single, blobby little cell-shaped thing moving down a slope,” Horsfield explained. “It was on fire and it was burning. I did that using sprites, which are basically just pictures on particles. If you want to make something nice and cloudy, for example, you can take a photograph of a cloud and put it on sprites.

Using new texture-mapping hardware and these fast Intel machines designed for games, you can draw millions of particles a second, all with pictures texture-mapped on them.

“So, for the Balrog, we shot fire— explosions and propane tanks going off, flames billowing and curling around— and then we put those pictures on fairly rudimentary Maya particle systems. Each particle was a picture of fire doing its stuff. We did the same thing for smoke. In both cases, the



pictures were animated, not just still, so they would evolve over time. There were a lot of these little sprite projections going, synchronized differently, and we layered them together until it looked appealing. We added fire where we felt we needed it, and took it away where it didn't seem to be working. So basically, we were just utilizing Maya as a compositing package to reposition the pieces of fire so that they were in the right place and moving the right way.

“The benefit of using this method was that we were rendering in hardware for most of it. We did do a couple of software layers, if we wanted things like volume shadows inside the smoke. But for the most part, it was rendered in hardware, using videogame technology. We got a big bank of incredibly fast machines; so, instead of rendering a frame every couple of hours, we were rendering a couple of frames per second.”

The encounter with the Balrog concludes with both the creature and Gandalf falling into the fiery abyss — a composite of a bluescreen high-speed breakaway bridge element, the CG creature, bluescreen actors, the digital doubles and matte painting extensions of a series of miniatures. “From the time they see the Balrog coming,” observed Alex Funke, “where Boromir runs through the doorway and almost falls over the edge of the cliff, to where Aragorn carries Frodo out at the end, it is almost completely miniature sets. I believe it is the longest continuous all-miniature sequence ever done for a film. The entire staircase is miniature, the great hall is miniature, the bridge of Kahazad-dûm is miniature— all fourteenth scale.”

A saddened fellowship exits Moria and makes its way to the refuge of Lothlórien, the forest kingdom of the elves. Referred to by Tolkien as ‘the City of the Trees,’ the production conceived Lothlórien as a city atop the trees. “Lothlórien was like the Swiss Family Robinson treehouse, combined with a grove of sequoias, combined with the Ewok village,” described Paul Lasaine. “Alan Lee did the hero design, and I did a number of illustrations of the entire village. The look was misty, ethereal. Peter Jackson kept saying to keep it ‘magical.’ He talked of an elvish white light, as if he wanted Lothlórien to seem like heaven.”

Lothlórien was realized in part through a full-size set featuring massive tree bases. Wider treetop views were relegated to the miniatures unit and shot by co-director of photography David Hardberger. Comprised of eight 36-foot-tall pieces representing the tops of the trees, the fourteenth-scale Lothlórien set measured approximately sixty by eighty feet and filled production's largest shooting stage— an enormous space within the area's tallest building, leased specifically for the Lothlórien shoot.



Members of the miniature photography unit prepare for a motion control shot of the giant statues. The eight-foot-tall figures were carved out of block urethane, then detailed with a surface coat of plaster. The rock faces behind them, like most others in the film, were produced by molding and casting actual rock surfaces. / A nearly minute-long shot begins on the fellowship canoeing the river, cranes up past the pillars and cliff face, then flies over one of the statue's outstretched arms to reveal, beyond its stern visage, an expansive misty lake. The shot was a combination of foreground miniature statues and rock, tiled mid-level imagery captured by the live-action scenic unit, and matte paintings projected onto a digital cyclorama to provide distant background and sky.

“Lothlórien was the most complex miniature we built,” asserted Richard Taylor. “Trees were sculpted, molded and sprayed up in urethane; and each one was about five to five and a half feet in diameter. To support the weight of their branches, they had massive steel armatures in them. We hand-applied more than 30,000 sprays of artificial leaves onto them, with 108 elven dwellings placed within the trees— huge spiral staircases weaving up the trunks. The dwellings were actually carved out of wax, and then we cast the urethane into the wax to give them the most organic feel that we possibly could.” *The Workshop* also built a ground-level twelfth-scale set of about a dozen trees for shots looking down through the treetops at the fellowship walk-ing below.

The shoot lasted four months, during which time Hardberger shot the miniatures in a thick, smoke-filled environment to create a misty feel. To maximize the sense of scale in wide shots, the miniatures were filmed in layers. “We shot a series of stacked layers as a multiplane in order to get enough distance out of it,” Alex Funke explained. “So, for example, we’d shoot five or six trees as our hero piece, which was as many as we could fit in and still have space to work. Then we’d shuffle them around, build the next layer back, pull the camera back, and shoot it again. And then shoot another layer behind that. Almost all the shots in that sequence were two or three layers deep in order to get enough trees.”

In addition to the miniatures and full-size set, Lothlórien required some digital tree extensions, composited into live-action plates in which the first unit had intentionally shot off the set of tree trunks— built up only to a certain point— and into the ceiling. Digital paint blended the live-action elements, which linked up to miniature elements, and finally to the digital extensions. “3D was used to blend the Lothlórien sets with the Lothlórien miniatures,” explained Wayne Stables. “We would take a pass from the set and a pass from the miniature, and project them onto fairly simple geometry and blend them together, while the camera was moving, to join the miniature passes to the set passes. I think that’s what made the environments so epic through the show— they were such a mixture of 2D compositing work, miniatures, matte paintings and 3D work to blend everything together. Stuff could be shot in pieces, and then blended to form a single environment.” Some of the Lothlórien shots were composited by Oktobor— a Wellington effects house headed by Dean Lyon— which also composited a handful of Rivendell shots.

In Lothlórien, the fellowship meets Galadriel (Cate Blanchett), queen of the elves, who conjures images of a disastrous Hobbiton future in her ‘mirror bowl’— an all too possible future if Frodo fails in his mission to destroy the ring. “Frodo sees a Hobbiton that is overrun by orcs and totally destroyed,” said Jeremy Bennett, who rendered a series of drawings and paintings to evolve the Hobbiton ruin look. “The hobbits are living above ground now, in shacks. There is a mill up on the hills, and it has been turned into a factory, puffing smoke. Debris is everywhere, and all of the trees are now just stumps. It’s very ugly. Peter’s overall brief was, ‘This has to look incredibly morose and dreary.’”

The final vision was a complex 3D composite awarded to Animal Logic, which assembled the photographic elements of a large mill-turned-factory miniature— designed by John Howe— and matte painted backgrounds. David Woodland designed the look of the water-filled vision bowl viewing plane. “The most complicated thing about it was trying to make it look watery and still get us into the Hobbiton scene,” noted Chris Godfrey. “We kept simplifying it until it became this watery

effect, a streaming montage of images with a light ray behind it.” Production had provided Animal Logic with multiple passes of the Hobbiton ruins from the model shoot. Animal Logic then composited in the montage of the model photography images, along with reflections of Frodo. “We developed a very simple program for the watery effect. We could simply type in a frame point and give it a location and say, ‘Okay, give us a droplet here, give us a droplet over there.’ It was a distortion effect that we did on Shake. We rendered the rays effect in RenderMan; and once we had that, we positioned those in Maya, then took the majority of it to Shake where we did most of the distortion as an overlay through this simple program that we wrote.”

While testing Frodo’s resolve against the ring’s power, Galadriel herself is tempted by the ring, and for a few brief moments, is transformed by Sauron’s evil spirit. The ‘scary Galadriel’ effect was farmed out to GMD, an Australian company, which was provided bluescreen shots of Cate Blanchett in an extreme, Kabuki-style makeup. “Since the makeup looked like makeup,” said Jim Rygiel, “the shots needed a lot of intricate 2D smoothing and colorizing. There weren’t a lot of heavy-duty effects shots; it was more of a post process, with color grading and 2D work.”

Peter Jackson’s brief to GMD was that Galadriel be ‘beautiful and terrible as the dawn’ in these shots — a description found in both the book and the script. Jackson also wanted the shots of Galadriel to possess a translucent quality, as if Galadriel herself were the light source, rather than a light being on or behind her. GMD designers achieved Galadriel’s translucence by isolating the natural highlights and midtones in the bluescreen plates of the actress into eighteen individual layers, with some layers containing several elements. The layers were then treated in 2D using Inferno and Flame, then recomposited.

The terrible future in store for Hobbiton and its inhabitants weighs heavily on Frodo as he and his companions leave Lothlórien and continue toward Mordor by canoe on the River Anduin, passing the Pillars of Argonath— towering stone statues of former kings, forebears of Aragorn, each with an outstretched hand. A nearly one-minute-long shot in the sequence starts on the canoes in the river, then cranes up over a rocky cliff face, flies over one of the outstretched statue arms and past the head toward a lake beyond. The shot was a combination of a miniature element, scenic tiles, matte paintings projected onto a digital cyclorama, and a computer generated river, boats and birds.

The statues, canyon and foreground rock face were all part of a miniature set built by the Weta Workshop and shot by Alex Funke. “That miniature set was the most fun to shoot,” Funke recalled, “because the statues were so beautifully carved and the whole set was so convincing. The modelers loved building it because it was a chance to do something really big. They went in and put bits of moss on the statues, little trees growing out of cracks in the rock and so forth.”

Tensions flare among the surviving members of the fellowship as they camp on the lake’s shores until nightfall. But they band together once again when



A recurring effect in the film is the Eye of Sauron, a visual manifestation of Sauron’s evil spirit. After a lengthy and difficult design evolution, the Eye of Sauron was finally conceived as a flaming cat’s eye. To achieve the effect, Weta Digital applied high-speed, live-action flame elements to particles surrounding a piece of taurus-shaped digital geometry. Manipulated practical elements— such as

attacked by the Uruk-hai, sent by Saruman to intercept them. In the course of the fellowship's fight with the Uruk-hai, Legolas demonstrates his superb, nearly supernatural, skill with the bow and arrow. Prior to the start of filming, and prior to the casting of Orlando Bloom as Legolas, Peter Jackson and Randy Cook had discussed how the elf warrior's bowmanship might best be achieved, and had decided to create all-digital arrows, with the actor simply miming the action. "Even Errol Flynn had experienced difficulty in smoothly 'nocking' his arrows—which is what it's called when you put the notch thing onto the string thing," remarked Cook. "So Peter and I figured that if Errol Flynn couldn't do it, whoever wound up playing Legolas wouldn't be able to do it, either. So we decided pretty early on to give it some digital help and have the actor just pantomiming the action, without really shooting arrows. He'd just reach for an invisible arrow, pull the string back, snap it and go for the next one. That way, he could shoot a perfect arrow every time." Legolas' skill was further enhanced by speeding up the action, making it appear as though he were shooting an arrow every second.

streaming dry ice vapor and underwater photography—created textures within the eye.

Recognizing that the fellowship is splintering and that he must continue on toward Mordor, Frodo slips away by canoe, alone save for the faithful Sam, who will not leave his master's side. Among the shots awarded to Animal Logic were those of Sam, unable to swim, sinking beneath the water when he follows Frodo in the canoe. Peter Jackson elected to shoot the scene dry-for-wet, with Sean Astin suspended on wires against greenscreen and shot at 150 frames per second as giant fans blew his hair and clothing. "I thought that by shooting it dry-for-wet we could concentrate more on the performance," Jackson explained. "It was a very important moment in the film, and I wanted Sean to concentrate on selling that moment, without worrying about drowning. The moment you put an actor inside a tank, trying to hold his breath and act at the same time, you introduce an enormous distraction. So it was a logistical decision, really—it just seemed easier to do it dry-for-wet."

Animal Logic provided computer generated effects that were composited with the dry-for-wet elements to make it appear as if Sam were actually underwater. "We put in all the bubbles, the flotsam and everything else," related Chris Godfrey. "We built a rough 3D model of Sean Astin, and put a lot of paint on top of it; and that became our collision object for the particle animation. In addition, we did all of the animated God-rays and the bubbles that were coming out of his mouth and off his clothing and swirling around him. We also produced a light dapple on him. There was a bit of a lighting effect on him in the greenscreen element, but we enhanced that just to make it better." Animal Logic art director Deborah McNamara designed the drowning shots, and Scott Townsend executed the particle animation in Maya, with composites done in Inferno.



A number of shots in the film feature views of Mount Doom, in the land of Mordor, where the menacing ring of power being borne by Frodo must be returned to be destroyed. Images of the volcanic mountain were created through digital matte paintings—for distant, relatively static shots requiring little parallax shift—and via a miniature. Model technician Kyle Gudsell readies the Mount Doom miniature for filming.

Film One ends, but the Ring cycle has only begun. By the time the last of the films is released in 2003, Peter Jackson and many of his Weta team will have invested eight years in *The Lord of the Rings*. In the high-tech visual effects realm, eight years is a very long time— long enough to see the development of multiple generations of technologies. “By the time we’re done with the trilogy,” mused Jon Labrie, “we will have changed a generation or two of equipment. A lot of the tools and techniques we have now will be totally redefined. They’ll have to be, since Film Two is twice as complex as Film One; and Film Three will be more complex, still.

“When I first considered being on *Lord of the Rings*, I thought it could be the coolest thing ever. But my next thought was that it could also be cheesy. After all, it is fantasy, and that’s difficult to do well. What was gratifying for me, personally, was to see what happened on the set and then look at the rushes and realize that the performances were really there, and know that the effects would not exist to prop up or make the film at all. The effects would just make better what was already a very solid story and a very good bit of filmmaking.”

Having completed *The Fellowship of the Ring*, but still heavily embroiled in day-to-day postproduction on *The Two Towers* and *The Return of the King*, Peter Jackson was just coming to grips with the sheer scope of the project he had taken on. “It seemed like a good idea one day to say, ‘Let’s do *The Lord of the Rings* and shoot all three movies back to back— wouldn’t that be great?’” commented Jackson. “And then you slowly start to work out the logistics, and you realize the size of the job. The enormity grows and the complexity grows as you go along, and it becomes a long strategic, difficult jigsaw puzzle that has to be figured out. But the way I countered that was by thinking: ‘Is there anything else I would prefer to be doing? Is there anything else in the world I’d rather be doing right now than making three *Lord of the Rings* movies back to back?’ And there wasn’t. In a way, the project’s enormity and complexity and the endurance it required were what made it worth doing in the first place. That was the whole point, in some respects. *The Lord of the Rings* could never have been made without that sort of commitment.”

For his part, Jackson garnered the strength to cope with the pressures of the huge production in an unusual, but wholly appropriate place. “When we were shooting Bag End scenes in the studio,” Jackson recalled, “we had this wonderful Hobbit hall with all these tunnels and bedrooms and dining rooms, and it was very peaceful and incredibly comforting. So I would just go on the set before the crew arrived in the morning and imagine myself sitting in Bag End. And then, later in the day, Ian McKellen would be there as Gandalf, and Ian Holm as Bilbo, and Elijah Wood as Frodo. I felt as if I was the luckiest guy in the world, really, because everyone else will get to see it on film, but I was one of the few who got to actually sit in Bag End with Gandalf and Frodo. It really did feel like a storybook come to life.”



After a fierce battle with the Uruk-hai— sent by Saruman to capture the ring — *The Fellowship of the Ring* concludes with Frodo and the inseparable Sam leaving the remaining members of the fellowship behind, and embarking on the final leg of their perilous journey alone. The closing shot of the picture finds the two hobbits— fearful, yet resolute— on a craggy mountaintop overlooking Mordor and the fiery Mount Doom.

In service to a dream of one day truly making that idyllic storybook place a reality, Jackson purchased the Bag End set from the production and had it put into storage. “I have every intent one day of finding a hillside, digging a big hole, and putting that set there, just to have it as a little weekend retreat,” Jackson mused. “It’s all in storage for some future hillside.”

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